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The Surface Temperature of a Tropical Island

by

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Approved for Distribution C. O'D. Iselin

C. O'D. Iselin, Department Chairman

Abstract

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A Richardson radiometer mounted in a C-54 aircraft was used to measure the apparent surface temperature of the island of Barbados, West Indies. Runs across the island at 1000 feet elevation were made on five days under synoptic conditions which varied from suppressed to strongly disturbed.

Auth.

Introduction

The recent emphasis by Dr. Joanne Malkus on weather modification and rainfall produced by local heat sources both artificial (1) and natural (2) prompted a field trip to Barbados in August and September 1963 to study the island as a heat source and rain producer. A C-54 aircraft operated by Woods Hole and specially instrumented for meteorological research was based on Barbados during this period and made radiometer runs over the island in order to obtain measurements of the radiative temperature of its surface. The radiometer (3) uses a thermistor bolometer as a detector and is exposed to radiation throught a coated silver chloride window. The instrument sees radiating surfaces in the atmospheric window, 8 - 12 μ , and water vapor and CO_2 in the atmosphere outside these wavelengths. Its field of view is about 50' x 50' at 1000 feet and proportionately less at lower altitudes.

It was hoped to be able to make measurements under varying synoptic conditions and, if possible, at several times during the day under each regime. Fortunately, the days picked to make the radiometer runs did give a good sampling of synoptic differences and a wide range of cloud conditions over the island. Below are listed the days on which runs were made, the classification of the day and times (local) of the runs.

August 12: Typical undisturbed island day

Run 1: 1318
Run 2: 1339
Run 4: 1409

August 13: Undisturbed island day

Run 1: 0824
Run 2: 0843
Run 3: 1309
Run 4: 1321
Run 5: 1749

August 26: Strongly disturbed day with rain

Run 1: 0951
Run 2: 1002
Run 3: 1334
Run 4: 1346

August 28: Very suppressed day

Run 1: 1123
Run 2: 1135

September 3: Weakly disturbed day (p.m.)

Run 1: 1611
Run 2: 1624

General Flight Procedure

The radiometer runs were made in easterly or westerly tracks across the island (see maps for each day) at an elevation of about 1000 feet. The radiometer and psychrograph records were simultaneously side marked when the plane entered or left the island to facilitate analysis.

In order to check the calibration of the radiometer and in order to assess the importance of radiation emitted by the atmosphere between the sea surface and the instrument, on one of the flights to the R.V. CRAWFORD (on station about 270 miles east of Barbados) several passes were made in the vicinity of the ship at varying altitudes down to 500 feet. In the lowest 2000' the apparent temperature of the sea surface decreased with increasing altitude at the rate of 1.5^{o}C per 1000 feet (Fig. 1). Similar values were found by Richardson and Wilkins (3) in the sub tropics over the ocean. A direct comparison was made with the water temperature measured from the ship and radioed to the aircraft. The discrepency between the radiometer temperature projected to sea level and the CRAWFORD thermistor water temperature measured at one meter was 0.25^{o}C.

Reduction of Radiometer Records

Using the temperature of the reference black body recorded by the operator at the start of a run as zero point and alloting the correct temperature spread as controlled by the gain setting the trace can be converted to apparent temperature. As described in the previous paragraph it is necessary to correct this temperature for the altitude of the aircraft above the island or sea. It was found convenient to perform this correction in two steps, 1.5°C was added for flight altitude (1000 feet) above sea level, a second correction (negative) was made for the varying altitude of the island above sea level.

The point on the coastline where the aircraft entered and left the island was determined from 16mm cine films taken during each flight. When these points had been located a cross-sectional profile of the island was drawn for each pass. A time scale was fitted to the island cross-section and the corrected temperatures from the radiometer record were determined, averaged over a five second period. At an average air speed of 70m/sec the radiative temperature is thus averaged over a path length of 350m and a width of 2-15m depending on height. By this averaging the fine structure of the radiometer trace (Fig. 2) becomes obliterated.

For comparative purposes it is more convenient to employ potential temperature rather than surface temperature. This was computed from the elevation of the island and the adiabatic lapse rate of temperature, the correction being 0.15°C per 50 feet.

The potential temperature of the air at flight level was determined from the psychrograph records which were read at 15 second intervals. They are computed with respect to a pressure of 1000 mb; a further calculation from the formula

$$\theta_{\text{sea level}} = \theta_{1000} \left(\frac{P_{\text{sea level}}}{1000} \right)^{2/7}$$

then permitted their comparison with the island potential temperatures. The sea level pressure was computed by adding 5 mb to the surface pressure at Seawell Airport, which is 50 meters above sea level.

Discussion of Data

August 12, 1963: undisturbed island day (see Fig. 4). The sounding from Seawell at 1235 LST (Fig. 5) shows a very moist layer from 950 mb to 820 mb. An all-sky camera located at Seawell Airport recorded an increase in cloudiness in the afternoon with one shower at the camera site at about 1530. Dr. Peter Saunders, one of the Woods Hole scientists on the trip, was working at the Florida State University radar installation at the airport and recorded rain over the island in small showers by 1400 LST. He also noted that clouds this day gave particularly strong signals for their size.

The aircraft made four flights over the island. Runs 1 and 2 over the more northerly portion of the island (the only runs that were made over this section) and Runs 3 and 4 over the southern part of the island (Fig. 3). Run 3 was not included as it was incomplete.

These runs (Figs. 6a, 6b, and 7) were made between 1315 and 1415 LST which is the time of day when the island is generally hottest. The island had developed a cloud street with clouds of 14-15,000 feet by 1500 (Fig. 4). The potential temperature of the island surface on all these runs shows peaks of 7 to 9°C warmer than the sea surface temperature and a mean of 5.2° warmer. In addition they show fluctuations in the surface potential temperature of up to 6°C. There is very little difference in the records for the northern section (rough and eroded) and the southern section (low and cultivated) despite the differences in terrain. Surface wind was 070° at 16 knots at 1235 LST.

<u>August 13, 1963</u>: undisturbed island day. There was less cloudiness in general on this day than on the 12th and by mid afternoon and evening there were few clouds over the island (Figs. 9 and 10). The all-sky camera shows no shower activity at Seawell during the day. The soundings made at Seawell and by the aircraft (Figs. 11 and 12) show a drying out above the 850 mb level in the afternoon. Winds were due east at 12 knots morning and evening but had shifted to 120° at 1100 LST.

The runs were made at three different times during the day, but all across the same central section of the island (Fig. 6). Runs 1 and 2 approximately 2½ hours after sun rise (Figs 13 and 14); Runs 3 and 4 around 1315 LST (Figs. 15 and 16), again the hot period of the day and Run 5 (Fig. 17) about 15 minutes before sunset. The morning runs show that the island potential temperature is up to 3°C warmer than the sea surface temperature, has a minimum value close to the latter and a mean 1.5° warmer. The potential temperature of the air measured at flight level was also very close to the sea surface values. By 1300 LST (Figs. 15 and 16) the temperature differences in the peaks have increased to about 6°C with the west coast appearing to be warmer. The mean potential temperature of the island is now 3.5° warmer than the sea surface temperature. Cold spots having a potential temperature close to the sea surface temperature are still evident. The potential temperature of the air at flight level shows a gradual increase of about 1°C across the island from east to west. This trend was not evident on the morning or evening runs. The most striking run is No. 5 (Fig. 17) at sunset when the island has become cooler than the surrounding water; the fluctuations are very small most less than 1°C. There was a small remnant, however, of the more northern cloud street left at this time (Fig. 10a).

August 26, 1963: a strong disturbance was influencing the Barbados area (Fig. 19). The film of the PPI scope at the FSU radar showed NNE-SSW oriented bands of clouds moving in a north-westerly direction from an area southeast of the island at 1200 LST to a position directly over Barbados by 1340. See Fig. 19. The Seawell sounding (Fig. 20) shows a very moist layer from the surface to 680 mb. The aircraft sounding made 1½ hours before indicates a slight drying between 900 - 850 mb. The surface wind was 085° at 08 knots during the morning runs and the same direction but 05 knots in the afternoon. The all-sky camera recorded the heaviest shower activity during the morning and again in the late afternoon. There was middle cloud present all day.

During Runs 1 and 2 (Figs. 21 and 22) the aircraft encountered rain which is evident on both the radiometer and psychrograph potential temperature plots. In rain (Run 2) the radiation potential temperature was very close to the sea surface value but peaked to between 2 and 4°C higher outside the rain areas. Runs 3 and 4 (Figs. 23 and 24) in the "hot" part of the afternoon show the island potential temperature is uniformly about 4°C warmer than the sea but has fluctuations of only 2°C.

August 28, 1963: a very suppressed day with extreme haziness (Fig. 26). Both the Seawell and aircraft soundings (Fig. 27) show very dry air above 930 mb in marked contrast to the soundings for the 26th. Surface wind was 090° at 10 knots. The all-sky camera (on from 0845 to 1400 LST) recorded no showers at Seawell. A 16mm cine camera, located at East Point lighthouse, recorded cumulus activity in the morning reaching the congestus stage by 1115 LST but then died out with very small clouds in the afternoon.

The data for Runs 1 and 2 and island map are shown in Figs. 25, 28 and 29. The difference between the potential temperature of the island averaged along the entire flight path and the sea surface temperature in $5^{o}C$. The cold spots are 2 - $3^{o}C$ warmer than the sea. As on the mid-day runs of the 13th, the potential temperature of the air at flight level shows a gradual increase of about $1^{o}C$ across the island.

<u>September 3, 1963</u>: a weakly disturbed day (p.m.) Fig. 31. The Seawell sounding (Fig. 32) at 0800 shows dry upper air, which may have become more moist as the 1115 aircraft sounding indicates. Films taken aboard the aircraft show cloud cover over the island to be average by 1130 with a cloud street beginning to form. There were large cbs evident to the southeast of the island as a disturbance passes the island to the south during the day. When the aircraft returned from its mission and made the radiometer runs at 1630 (Fig. 31) there was middle cloud completely covering the island. The only island clouds were the remnants of the cloud street.

Runs 1 and 2 (Figs. 33 and 34) show the island to be cooling off with only one small peak on Run 1 in the middle of the island. Run 2 shows less temperature fluctuation than the later run on August 13th, but the average potential temperature of the island is still $0.4^{o}C$ warmer than the water.

<u>Summary</u>:

Figure 35 summarizes the results of all the radiometer runs, with the following points evident:

1) There is a diurnal variation of the surface temperature of the island with a maximum between 1330 and 1430 hours local time.

2) By sunset the island temperature is slightly lower than the

sea surface tmeperature.

3) On disturbed (wet and cloudy) days the temperature excess is only about ½ that of fine days.

4) During daylight hours "cold" spots may be found on the island where the island potential temperature is close to the sea surface temperature.

These results are what would be expected in view of the fact that what the radiometer "sees" is a mixture of the canopy of trees, cane, grass and bare ground. The radiating temperature of this type of vegetation is close to or even somewhat lower than the air temperature (4), whilst the radiating temperature of bare ground in tropical sunshine may be 20° to 30°C higher than the air temperature at screen level (5).

Acknowledgements

If it had not been for Mr. C.H. Wilkens participation in the Barbados field program there would have been no radiometer records to study. His skillful running of the radiometer and general enthusiasm in the field as well as his guidence in the reduction of the records were invaluable. Capt. Ewing and the crew of the C-54 aircraft must also be commended for their extremely competent flying of the exacting runs. Dr. Saunders has been most helpful in giving discussion time and information to this study. Mr. Michael Garstang of Florida State University has made temperature data available from his field program on the island. Mrs. Jacqueline Webster provided help in programming the psychrograph data for the GE 225 computer and Mr. Claude Rönne furnished all the photographs.

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2) Malkus, J.S., 1963: Tropical rain induced by a small natural heat source. Journal of Applied Met., Vol. 2, 547-556.

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4) Monteith, J.L. and G. Szeicz, 1962: Radiative temperature in the heat balance of natural surfaces. Quar. Jour. Roy. Met. Soc., 88, 496-507.

5) Geiger, R., 1950: The Climate near the Ground. Harvard University Press.

Titles for Illustrations

1) Graph of radiometer calibration check made August 24, 1963. Apparent sea surface temperature plotted against flight altitude in feet. The x is the water temperature measured from the R.V. CRAWFORD.

2) Sample radiometer record. Right hand trace shows temperature variation. Left hand trace is reference bath temperature.

3) Topographic map of Barbados showing traverses of aircraft over the island on August 12. The arrow offshore shows approximate location of aircraft when photo of island cloud cover was taken. Arrow at Seawell shows direction and speed of surface wind.

4) Photograph taken off NNE corner of island showing cloud cover over Barbados on August 12 at about 1445 LST.

5) Tephigram of Aug. 12 (1900 LST) sounding from Seawell. Solid line is temperature in ^{o}C; dashed line is dewpoint ^{o}C.

6) Graphs of radiometer runs August 12. Cross-sectional profile of island at bottom of graph. Island temperature ^{o}C corrected for variation in island elevation (solid curve) and potential temperature ^{o}C of island reduced to sea level (dotted curve).

    a) Run 1 (1318 LST)
    b) Run 2 (1339 LST)

7) Graph of radiometer Run 4, Aug. 12 (1410 LST). Cross-sectional profile of island at bottom of graph. Island temperature ^{o}C corrected for variation in island elevation (solid curve) and potential temperature ^{o}C of island reduced to sea level (dotted curve).

8) Topographic map of Barbados showing traverses of aircraft over the island August 13. Arrows offshore show approximate position of aircraft when photos of island cloud cover were taken. Arrows at Seawell show direction and speed of surface wind.

9) Photographs showing cloud cover over island August 13.

   1) Off north coast at about 1000 LST
   2) Off SSW coast at about 1000 LST

10) Photographs showing cloud cover over island on August 13.

   1a) Off NE coast at about 1800 LST
   2a) Off west coast at about 1800 LST

11) Tephigram of August 13 (0800 LST) sounding from Seawell. Heavy solid line is temperature ^{o}C; dashed line is dewpoint ^{o}C. The aircraft sounding made off SW coast of Barbados at 0930 LST is also plotted. Light solid line is dry bulb temperature ^{o}C; dotted line is dewpoint.

12) Tephigram of August 13 (1910 LST) sounding from Seawell. Heavy solid line is temperature ^{o}C; dashed line is dewpoint ^{o}C. The aircraft sounding made NE of the island at 1800 LST is also plotted. Light solid line is dry bulb temperature ^{o}C; dotted line is dewpoint.

13) Graph of radiometer Run 1, Aug. 13 (0824 LST). Cross-sectional profile of island at bottom of graph. Island temperature ^{o}C corrected for variation in island elevation (solid curve) and potential temperature of island reduced to sea level (dotted curve). Flight level potential temperature for 1000 mb and sea level (dotted lines). Air temperatures at 0800 for Brace, Seawell and East Point lighthouse are also plotted.

14) Graph of radiometer Run 2, Aug. 13 (0844 LST). Cross-sectional profile of island at bottom of graph. Island temperature ^{o}C corrected for variation in island elevation (solid curve) and potential temperature of island reduced to sea level (dotted curve). Flight level potential temperature for 1000 mb and sea level (dotted lines). Air temperatures at 0900 for Brace, Seawell and East Point lighthouse are also plotted.

15) Graph of radiometer Run 3, Aug. 13 (1309 LST). Cross-sectional profile of island at bottom of graph. Island temperature ^{o}C corrected for

variation in island elevation (solid curve) and potential temperature of island reduced to sea level (dotted curve). Flight level potential temperature for 1000 mb and sea level (dotted lines). Air temperatures at 1300 for Brace and Seawell are also plotted.

16) Graph of radiometer Run 4, Aug. 13 (1322 LST). Cross-sectional profile of island at bottom of graph. Island temperature ^{o}C corrected for variation in island elevation (solid curve) and potential temperature of island reduced to sea level (dotted curve). Flight level potential temperature for 1000 mb and sea level (dotted lines). Air temperatures at 1300 for Brace and Seawell are also plotted.

17) Graph of radiometer Run 5, Aug. 13 (1750 LST). Cross-sectional profile of island at bottom of graph. Island temperature ^{o}C corrected for variation in island elevation (solid curve) and potential temperature of island reduced to sea level (dotted curve). Flight level potential temperature for 1000 mb and sea level (dotted lines). Air temperatures at 1800 for Brace, Seawell and East Point lighthouse are also plotted.

18) Topographic map of Barbados showing traverses of aircraft over island on August 26. Arrows offshore show approximate position of aircraft when photos of island cloud cover were taken. Arrow at Seawell shows direction and speed of surface wind.

19) Photographs showing cloud cover over island August 26.

    1) OFF east coast at about 1300 LST
    2) Off NE coast at about 1300 LST
    3) Photograph of radar PPI scope located at Seawell Airport showing echoes at 1340 LST when radiometer runs were made.

20) Tephigram of August 26 (1530 LST) sounding from Seawell. Heavy solid line is temperature ^{o}C; dashed line is dewpoint ^{o}C. The aircraft sounding made east of the island at 1400 LST is also plotted. Light solid line is dry bulb temperature ^{o}C; dotted line is dewpoint.

21) Graph of radiometer Run 1, Aug. 26 (0951 LST). Cross-sectional profile of island at bottom of graph. Island temperature °C corrected for variation in island elevation (solid curve) and potential temperature of island reduced to sea level (dotted curve). Flight level potential temperature for 1000 mb and sea level (dotted lines). Air temperatures at 1000 for Brace, Rockley and Seawell are also plotted.

22) Graph of radiometer Run 2, Aug 26 (1003 LST). Cross-sectional profile of island at bottom of graph. Island temperature °C corrected for variation in island elevation (solid curve) and potential temperature of island reduced to sea level (dotted curve). Flight level potential temperature for 1000 mb and sea level (dotted lines). Air temperatures at 1000 for Brace, Rockley and Seawell are also plotted.

23) Graph of radiometer Run 3, Aug. 26 (1334 LST). Cross-sectional profile of island at bottom of graph. Island temperature °C corrected for variation in island elevation (solid curve) and potential temperature of island reduced to sea level (dotted curve). Flight level potential temperature for 1000 mb and sea level (dotted lines).

24) Graph of radiometer Run 4, Aug. 26 (1346 LST). Cross-sectional profile of island at bottom of graph. Island temperature °C corrected for variation in island elevation (solid curve) and potential temperature of island reduced to sea level (dotted curve). Flight level potential temperature for 1000 mb and sea level (dotted lines).

25) Topographic map of Barbados showing traverses of aircraft over island on August 28. Arrow offshore shows approximate location of aircraft when photograph of island cloud cover was taken. Arrow at Seawell shows direction and speed of surface wind.

26) Photograph taken off west coast of island showing cloud cover over Barbados on August 28 at about 1150 LST.

27) Tephigram of August 28 (0800 LST) sounding from Seawell. Heavy solid line is temperature °C; dashed line is dewpoint °C. The aircraft sounding made south of the island at 1200 LST is also plotted. Light solid line is dry bulb temperature °C; dotted line is dewpoint.

28) Graph of radiometer Run 1, Aug. 28 (1123 LST). Cross-sectional profile of island at bottom of graph. Island temperature °C corrected for variation in island elevation (solid curve) and potential temperature of island reduced to sea level (dotted curve). Flight level potential temperature for 1000 mb and sea level (dotted Lines). Air temperatures at 1100 for Brace, Rockley and Seawell are also plotted.

29) Graph of radiometer Run 2, Aug. 28 (1135 LST). Cross-sectional profile of island at bottom of graph. Island temperature °C corrected for variation in island elevation (solid curve) and potential temperature of island reduced to sea level (dotted curve). Flight level potential temperature for 1000 mb and sea level (dotted lines). Air temperatures at 1130 for Brace, Rockley and Seawell are also plotted.

30) Topographic map of Barbados showing traverses of aircraft over island on September 3. Arrow offshore shows approximate location of aircraft when photograph of island cloud cover was taken. Arrow at Seawell shows direction and speed of surface wind.

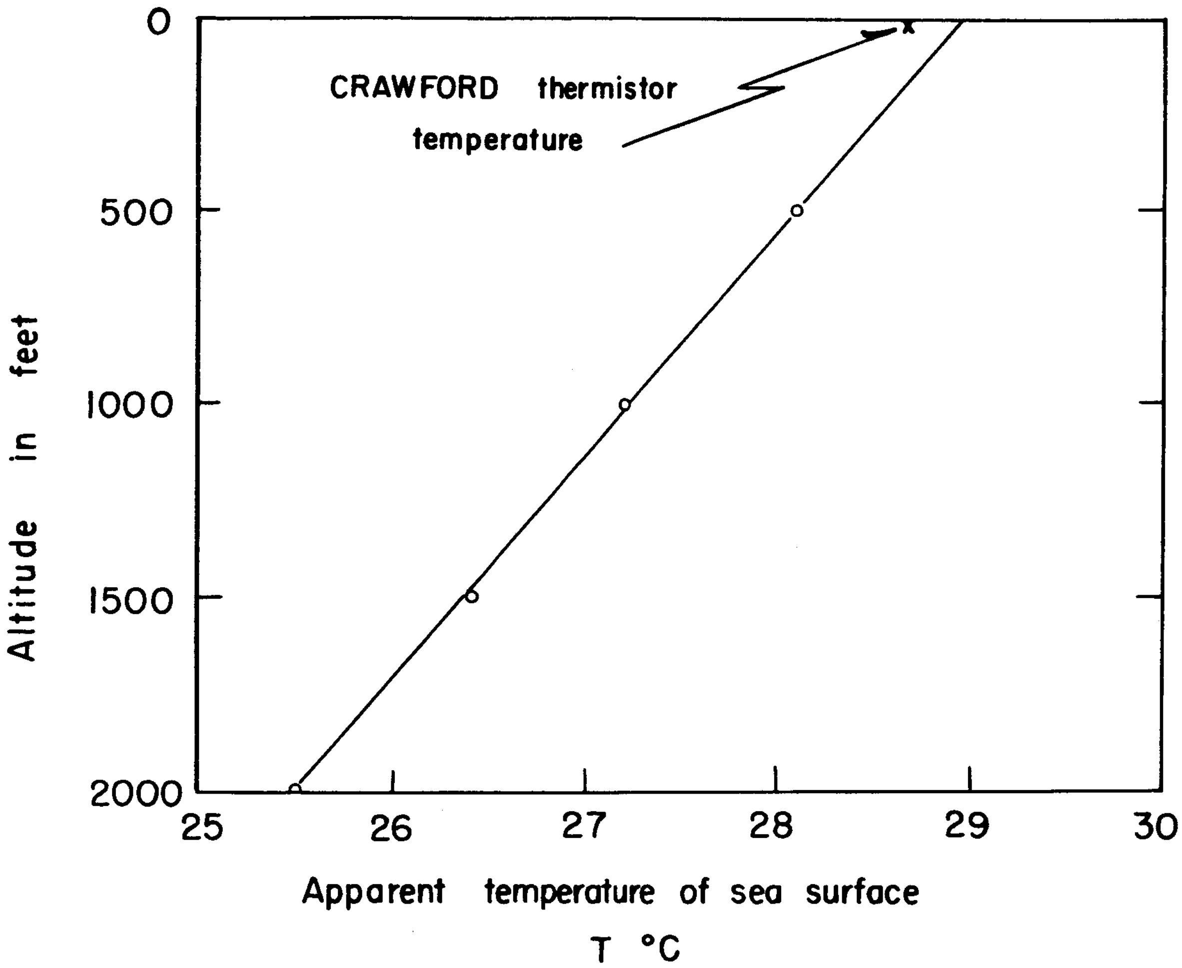
31) Photograph taken off NNE corner of island showing cloud cover over Barbados on September 3 at about 1530 LST.

32) Tephigram of Sept.3 (0800 LST) sounding from Seawell. Heavy solid line is temperature °C; dashed line is dewpoint °C. Two aircraft soundings made off the east coast at 1115 and off the NW corner of the island at 1600 are also plotted. Light solid lines are dry bulb temperatures °C; dotted lines are dewpoint °C.

33) Graph of radiometer Run 1, Sept. 3 (1612 LST). Cross-sectional profile of island at bottom of graph. Island temperature ^{o}C corrected for variation in island elevation (solid curve) and potential temperature of island reduced to sea level (dotted curve). Flight level potential temperature for 1000 mb and sea level (dotted lines). Air temperatures at 1600 for Brace, Rockley and Seawell are also plotted.

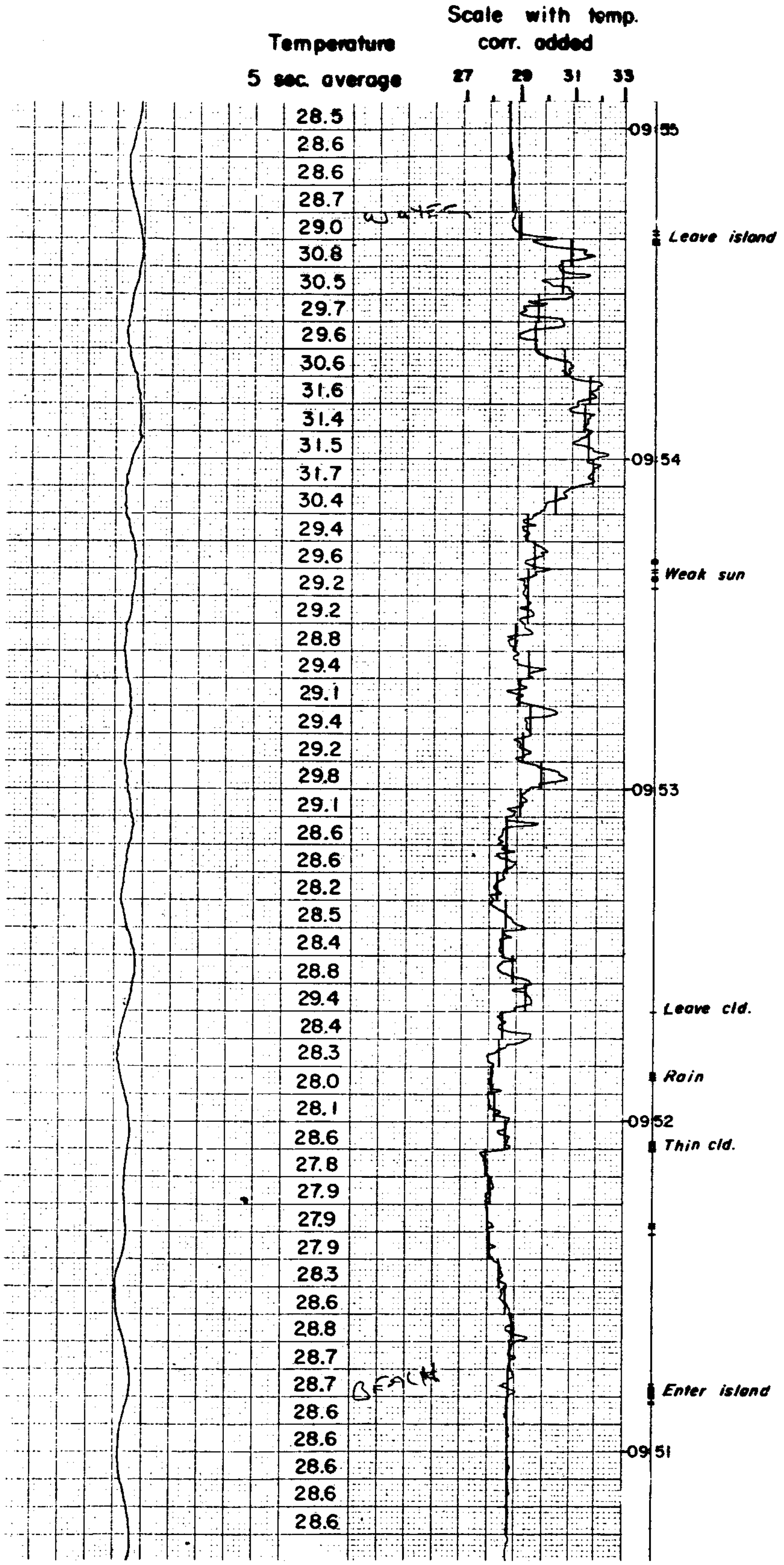
34) Graph of radiometer Run 2, Sept. 3 (1624 LST). Cross-sectional profile of island at bottom of graph. Island temperature ^{o}C corrected for variation in island elevation (solid curve) and potential temperature of island reduced to sea level (dotted curve). Flight level potential temperature for 1000 mb and sea level (dotted lines). Air temperatures at 1600 for Brace, Rockley and Seawell are also plotted.

35) Graph showing temperature variations for all runs. The lines show the difference between the average potential temperature of the island and mean sea level temperature. The cross-bars on the lines are the lowest potential temperature of the island minus mean sea level. The x's indicate the highest potential temperature of the island minus mean sea level temperature.



0
500
1000
1500
2000
Altitude in feet
CRAWFORD thermistor
temperature
25
26
27
28
29
30
Apparent temperature of sea surface
T °C

FIG. I



August 26, 1963

Run I 0950 LST

280° MH 1000 Alt.

Altitude Correction: +1.5 °C

Chart Speed 1mm / sec

Gain: x 50

Full Scale = 10° C

FIG. 2

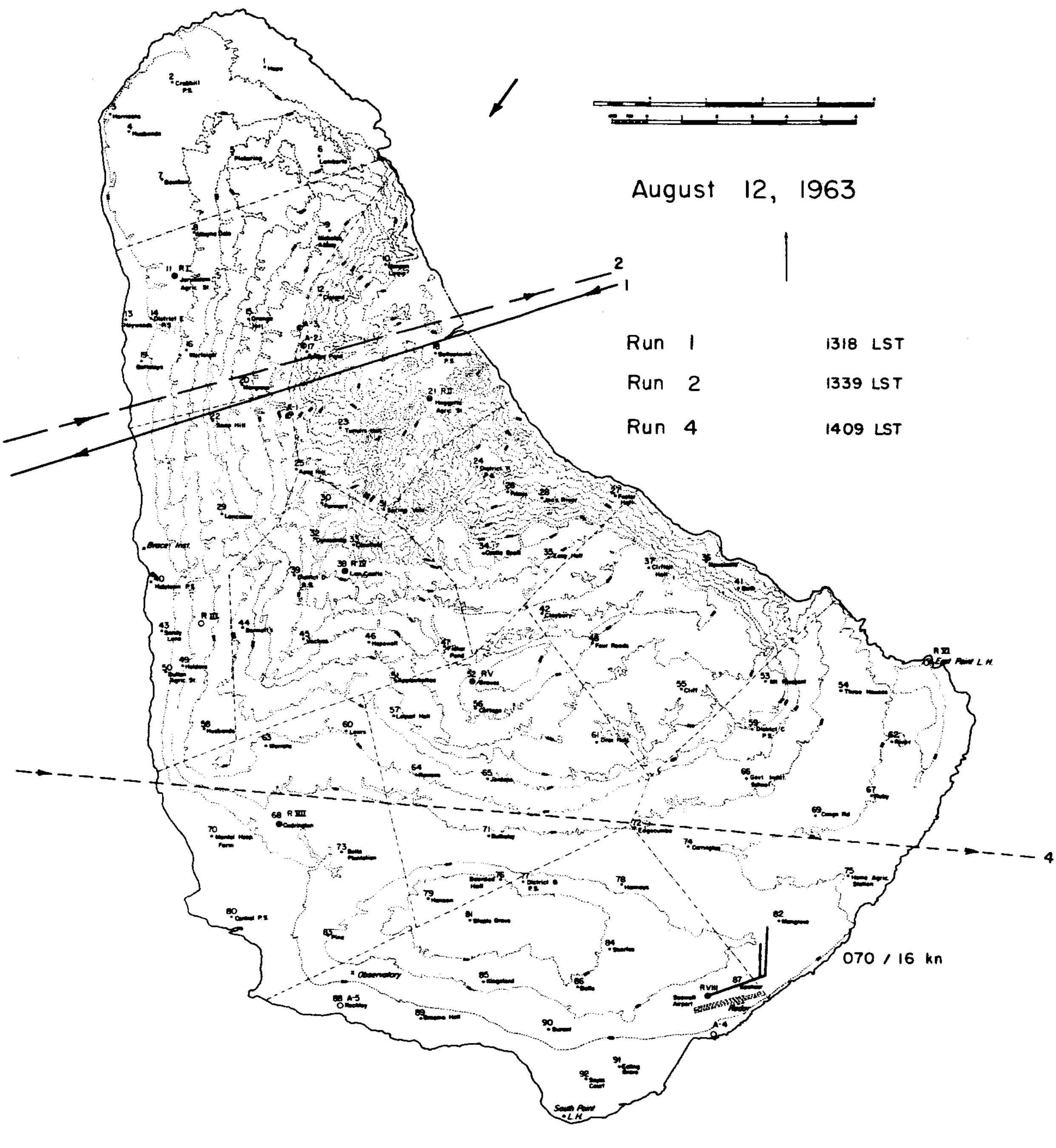
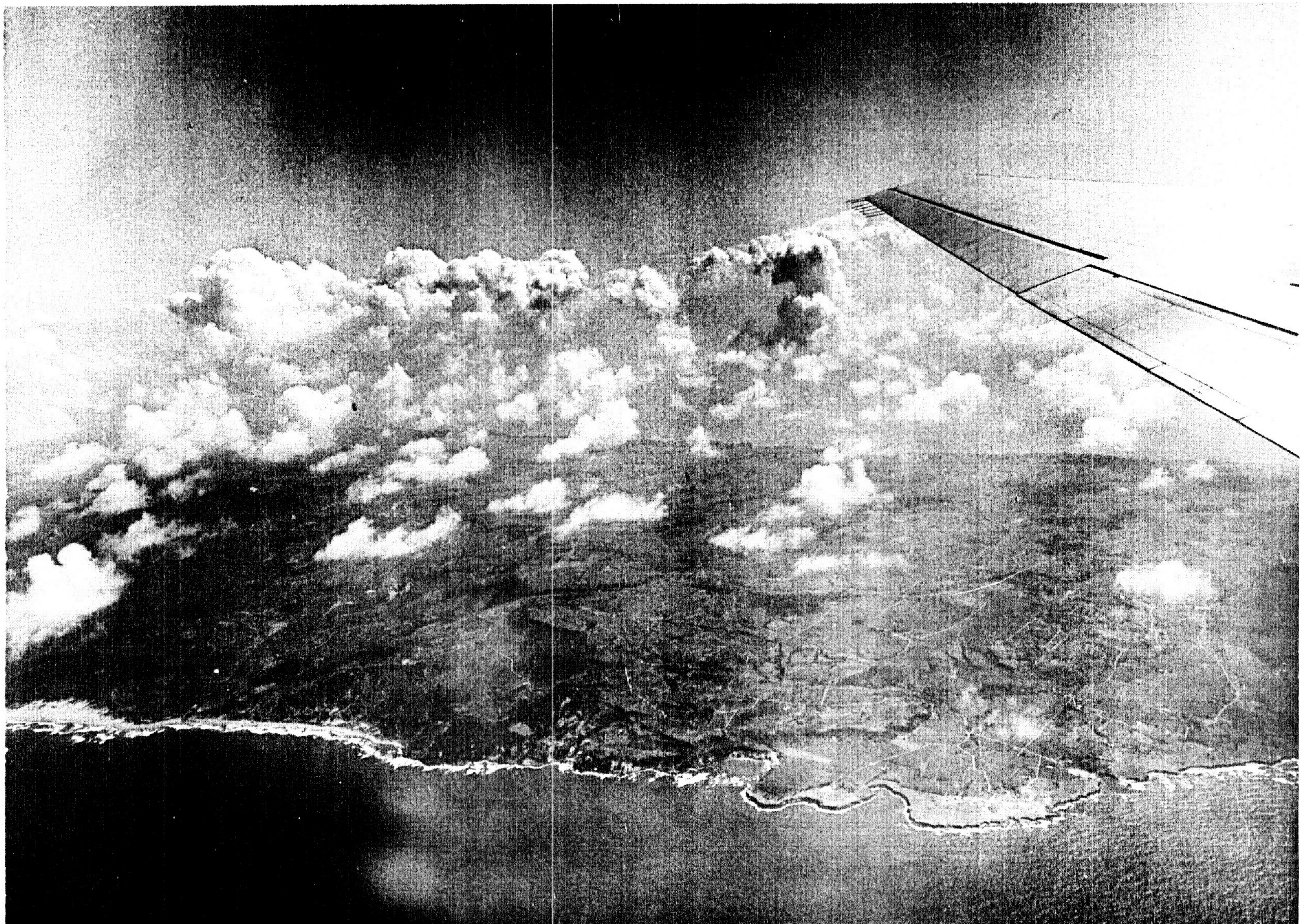
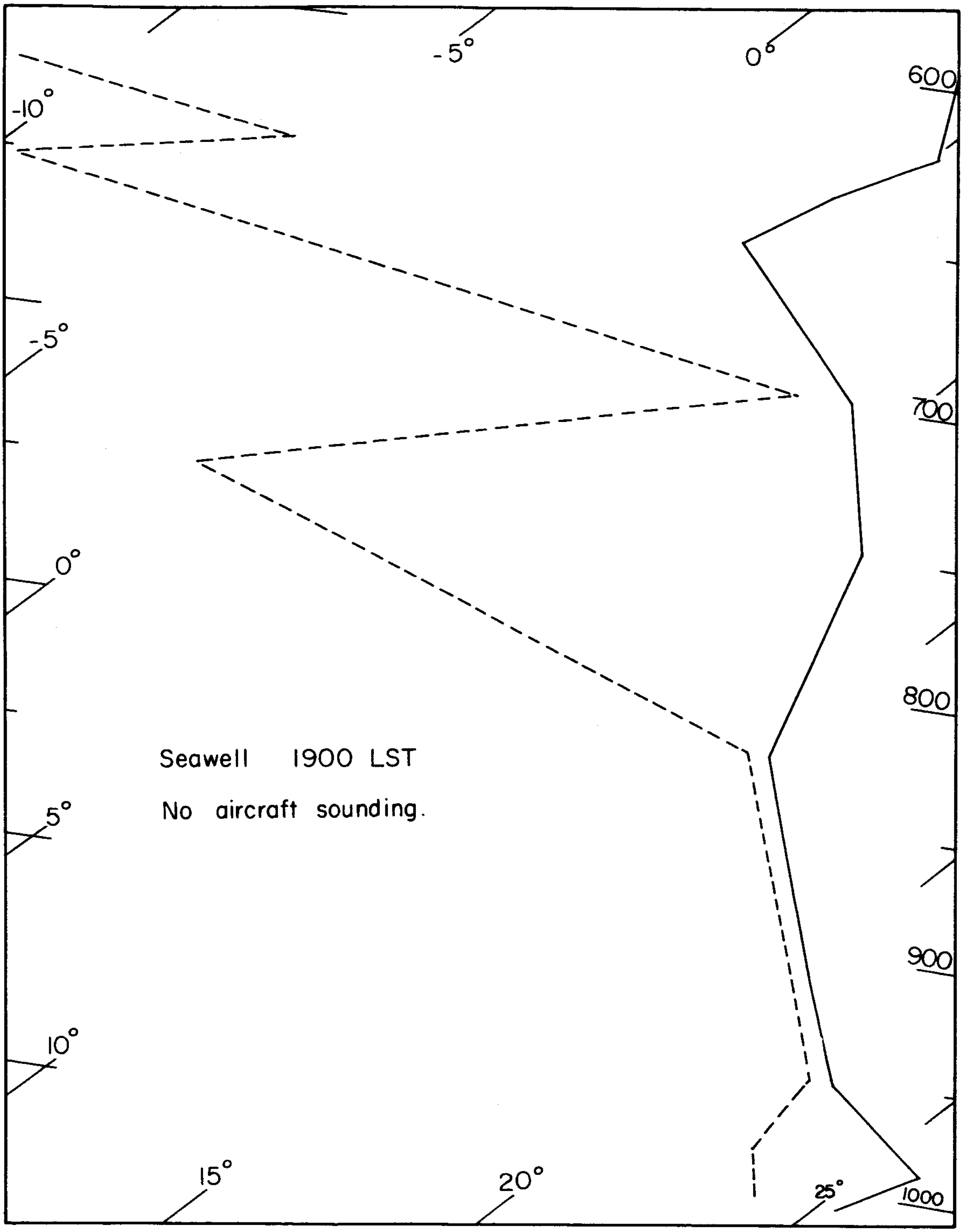

August 12, 1963
Run 1 1318 LST
Run 2 1339 LST
Run 4 1409 LST
070 / 16 kn
1
2
4

FIG. 3



Aug. 12, 1963 ~ 1445

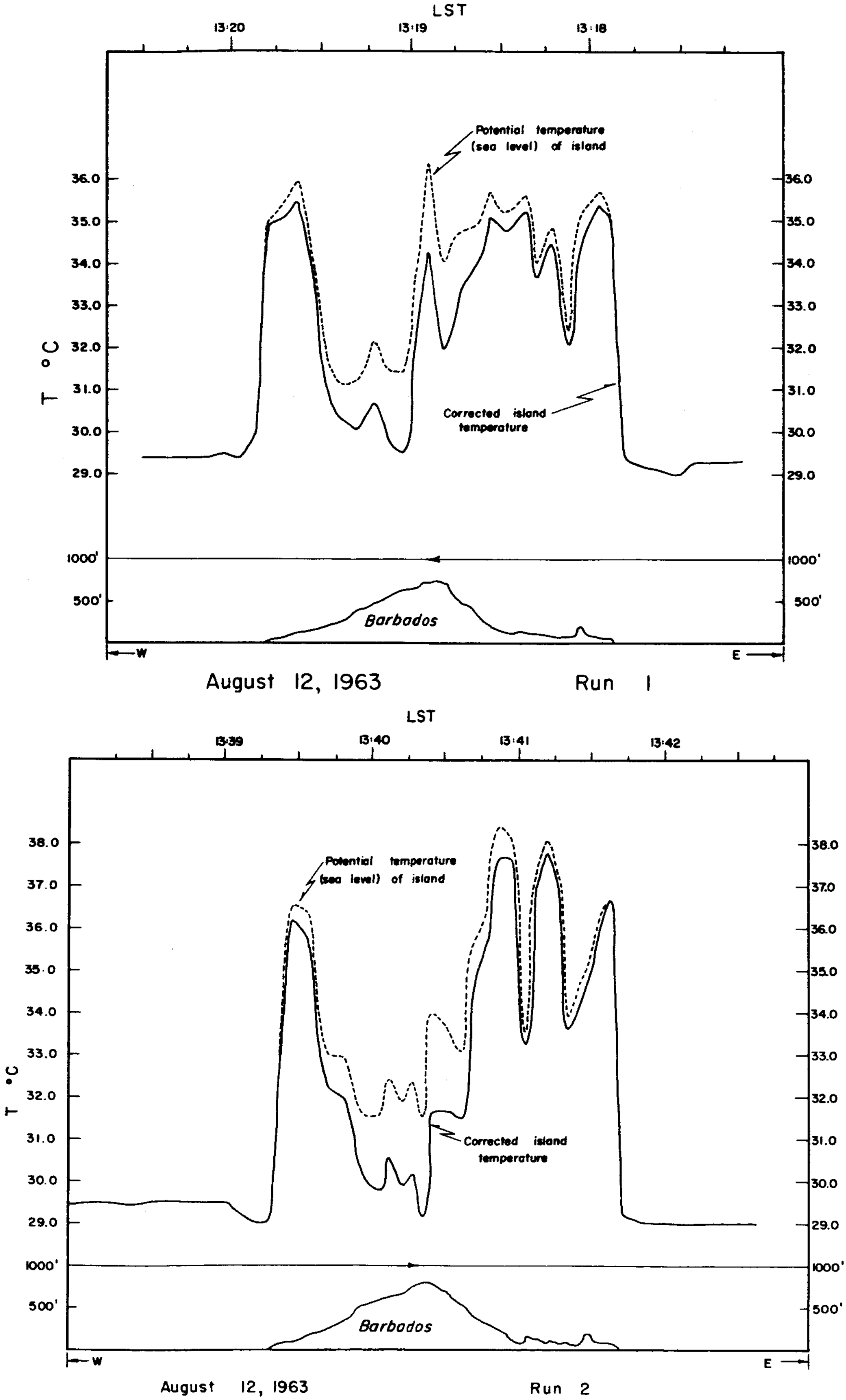
FIG. 4



August 12, 1963

Surface Wind: 070/16 at 1235 LST

FIG. 5



LST
13:20
13:19
13:18
Potential temperature (sea level) of island
Corrected island temperature
36.0
35.0
34.0
33.0
32.0
31.0
30.0
29.0
T °C
1000'
500'
Barbados
W
E
August 12, 1963
Run 1
LST
13:39
13:40
13:41
13:42
38.0
37.0
36.0
35.0
34.0
33.0
32.0
31.0
30.0
29.0
T °C
Potential temperature (sea level) of island
Corrected island temperature
1000'
500'
Barbados
W
E
August 12, 1963
Run 2

FIG. 6

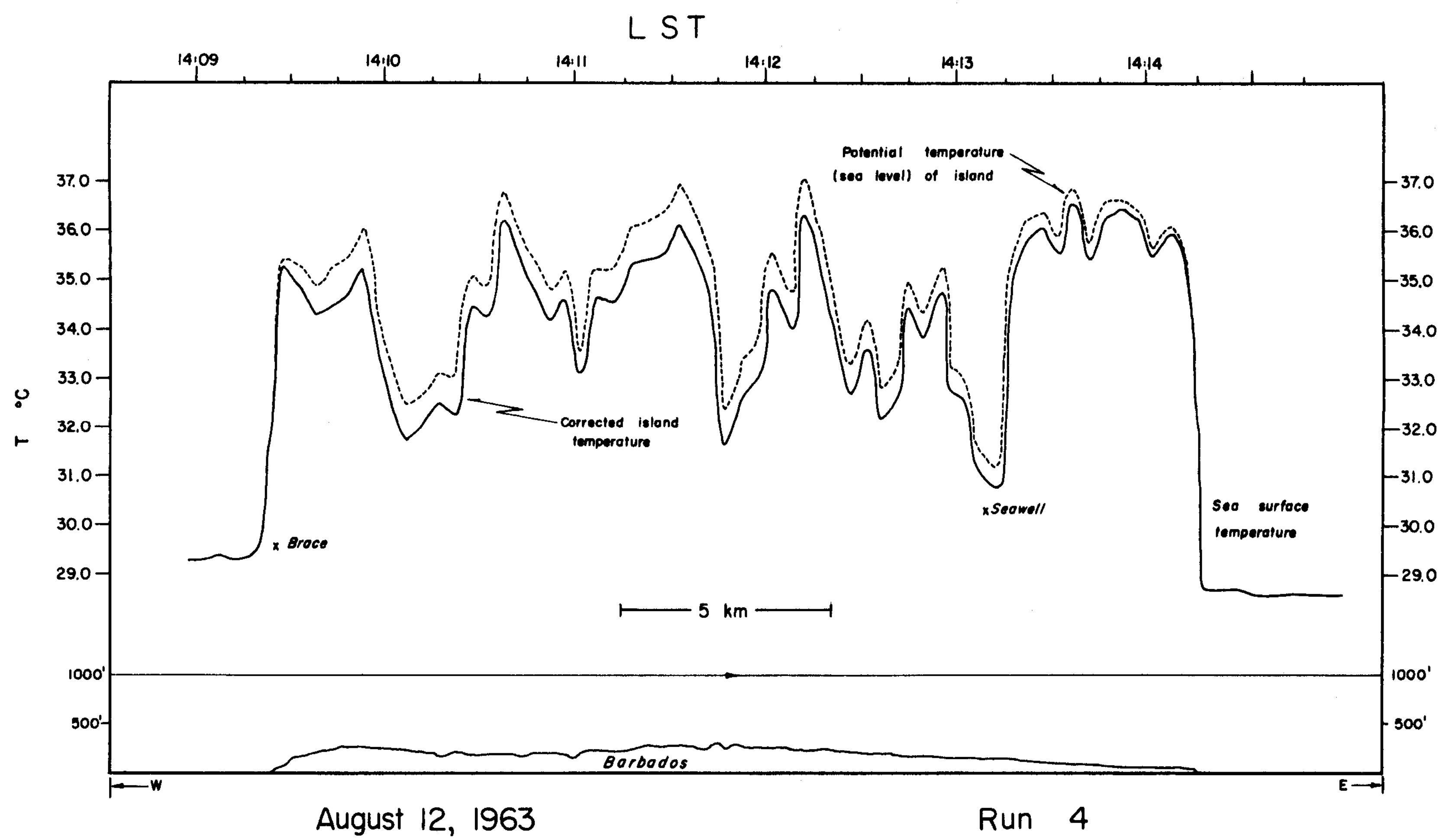
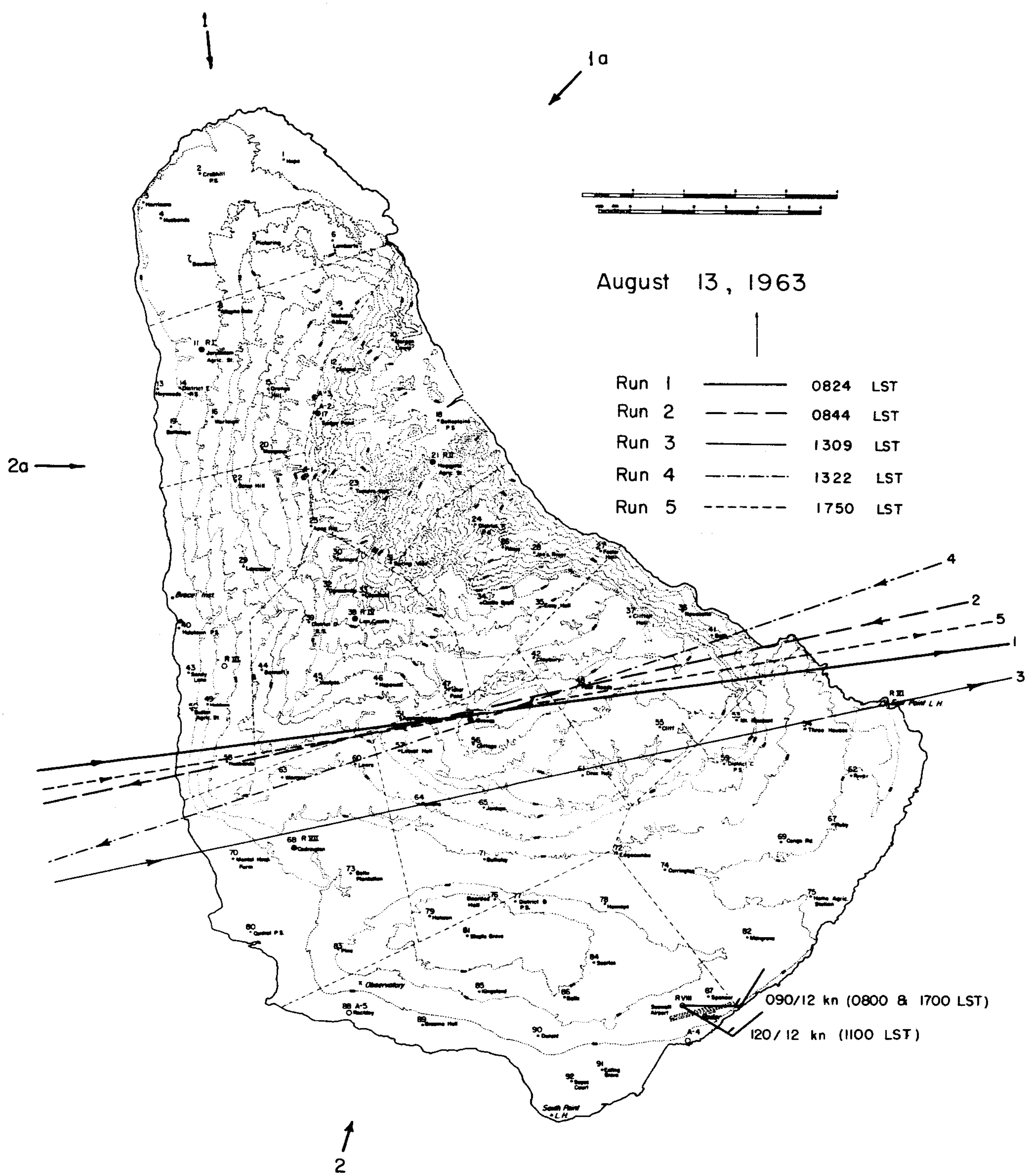

L ST
14:09
14:10
14:11
14:12
14:13
14:14
T °C
37.0
36.0
35.0
34.0
33.0
32.0
31.0
30.0
29.0
Potential temperature
(sea level) of island
Corrected island
temperature
x Brace
x Seawell
Sea surface
temperature
5 km
1000'
500'
Barbados
W
E
August 12, 1963
Run 4

FIG. 7



August 13, 1963
Run 1 0824 LST
Run 2 0844 LST
Run 3 1309 LST
Run 4 1322 LST
Run 5 1750 LST
090/12 kn (0800 & 1700 LST)
120/12 kn (1100 LST)
1
1a
2
2a

FIG. 8

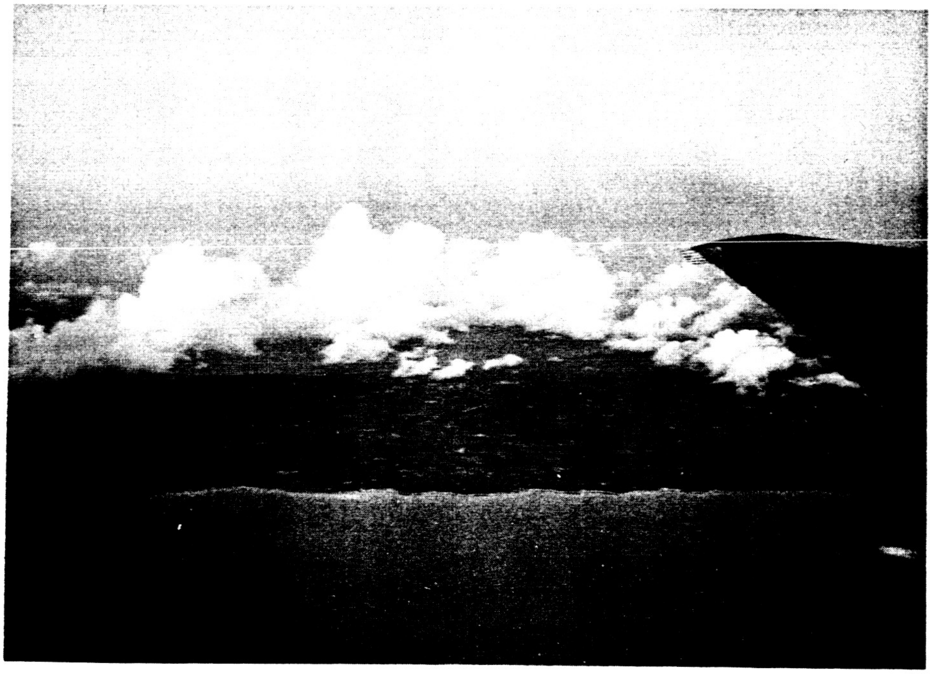
1

2

August 13 1000 LST

FIG. 9

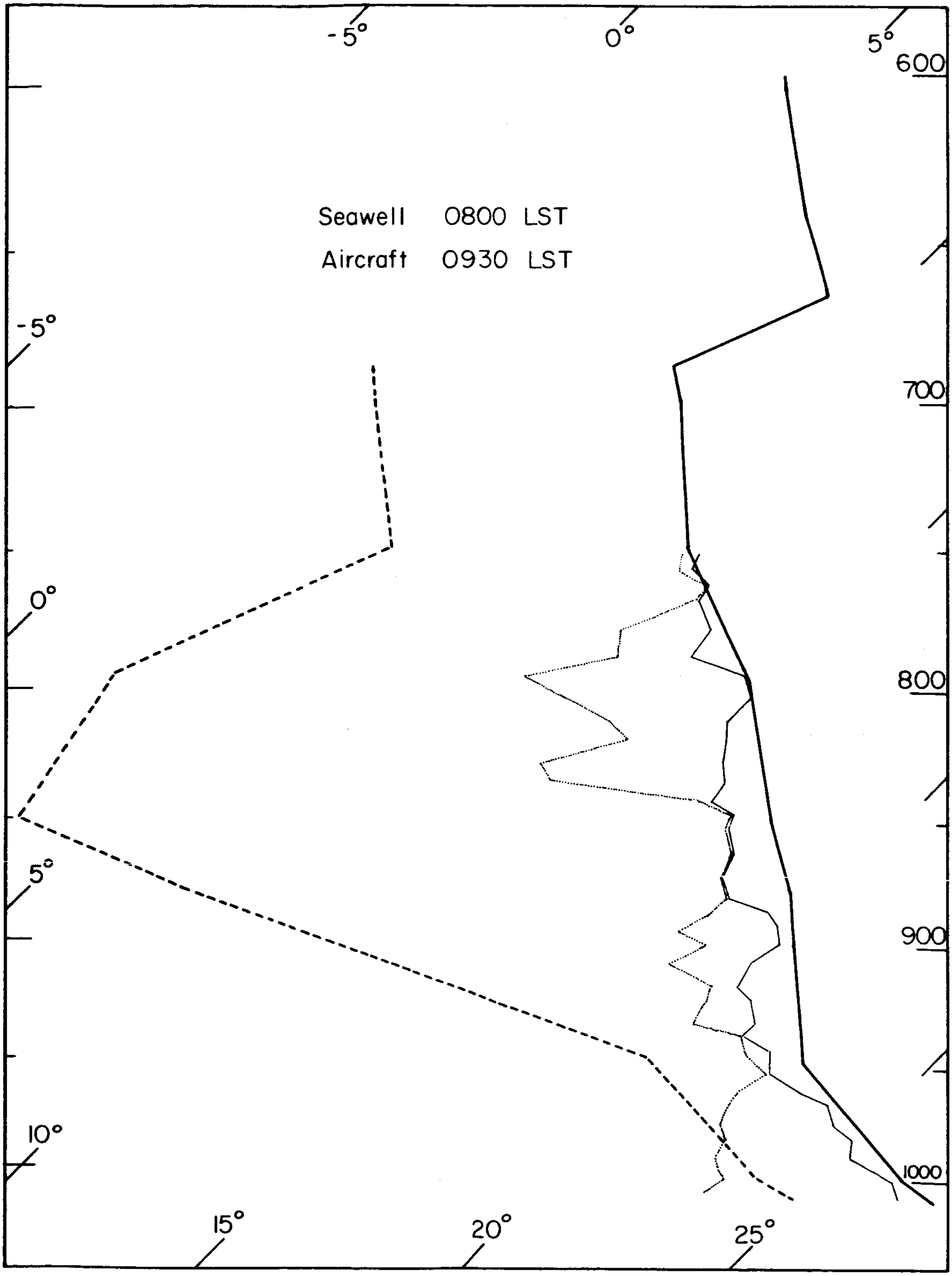
1a



2a

August 13 1800 LST

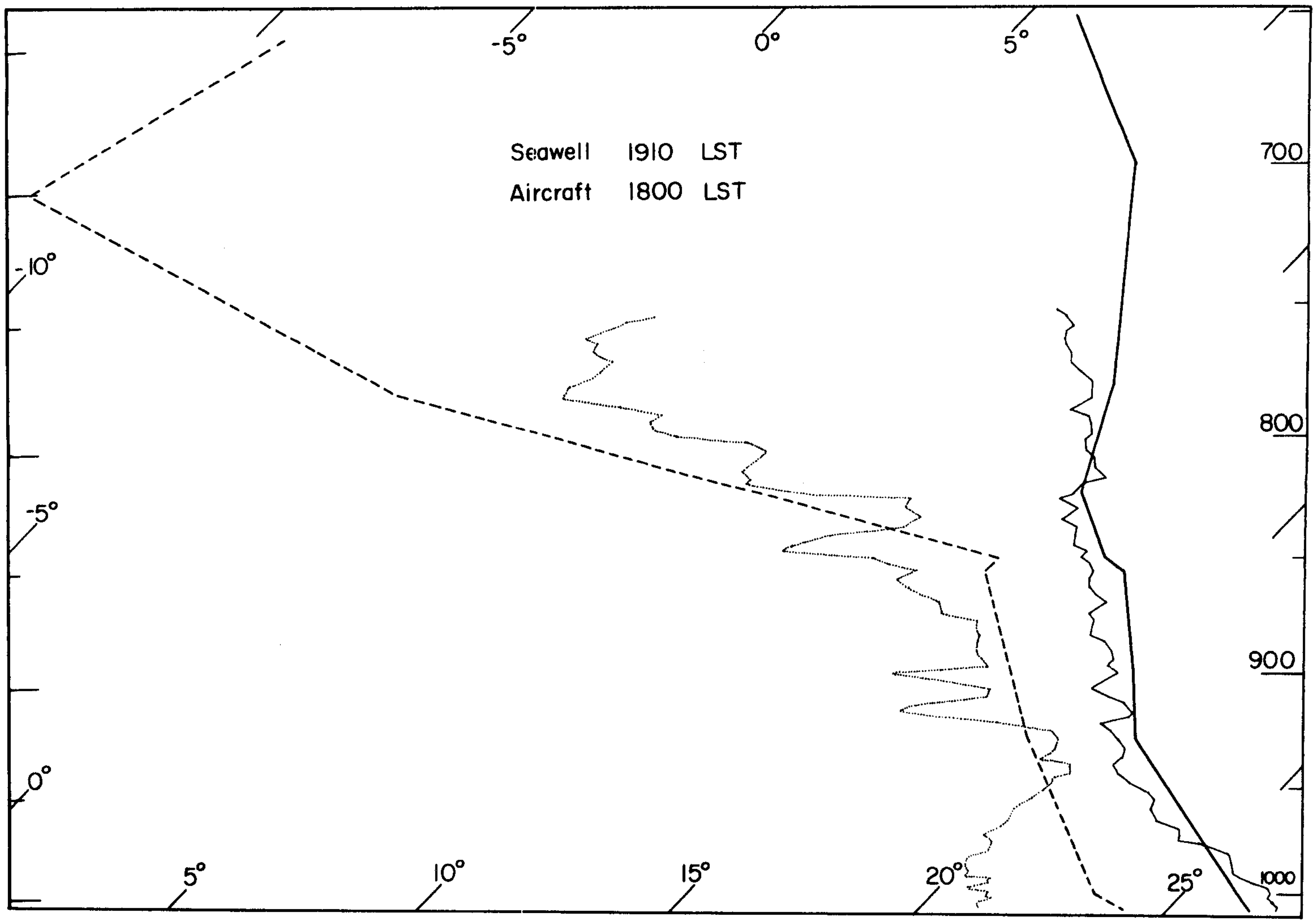
FIG. 10



August 13, 1963

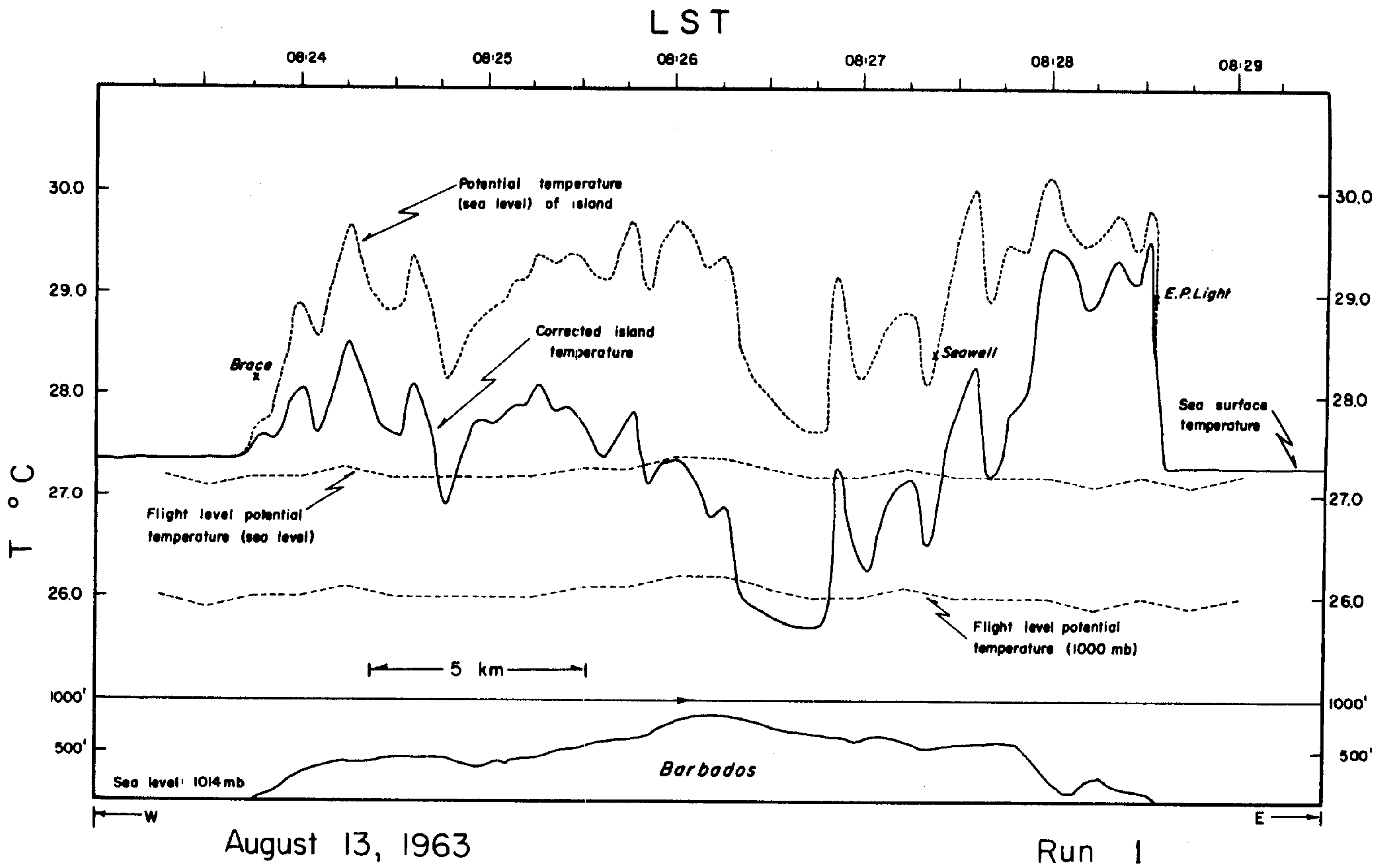
Surface Wind: 090/12 at 0800 LST
120/12 at 1100 LST

FIG. 11



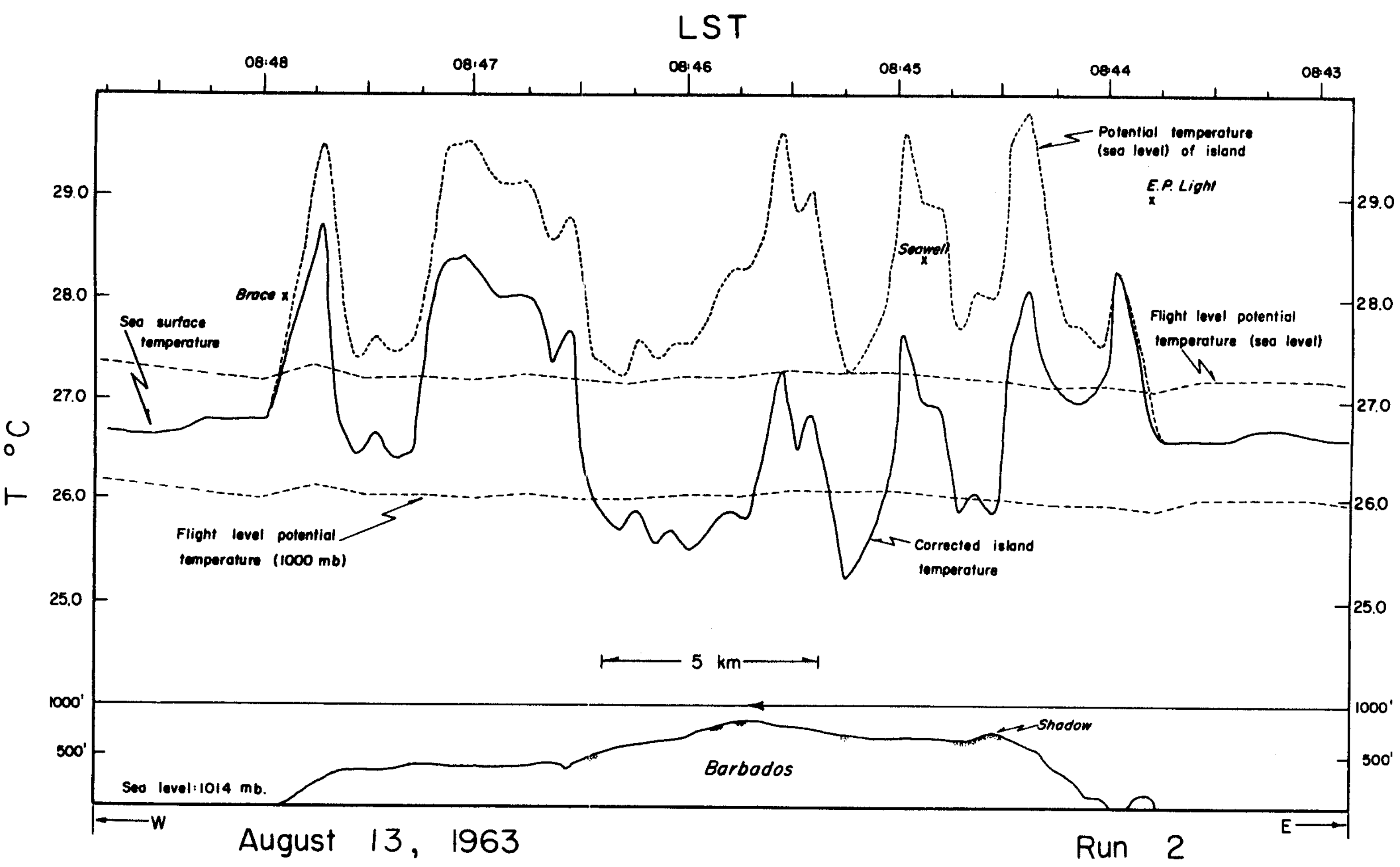
August 13, 1963
Surface Wind: 090/12 at 1711 LST

FIG. 12



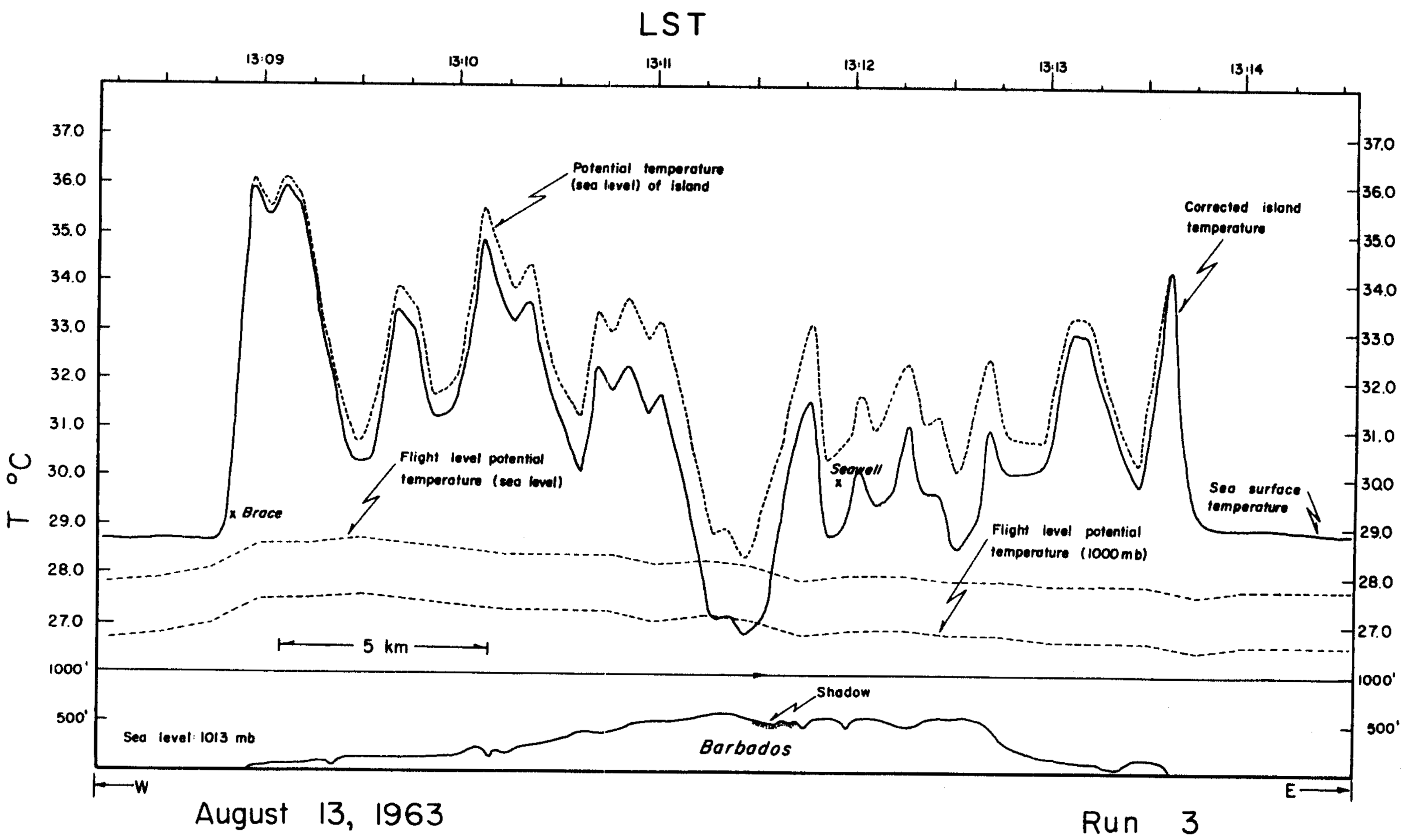
LST
08:24
08:25
08:26
08:27
08:28
08:29
T °C
30.0
29.0
28.0
27.0
26.0
1000'
500'
Potential temperature (sea level) of island
Corrected island temperature
Brace
Seawell
E.P. Light
Sea surface temperature
Flight level potential temperature (sea level)
Flight level potential temperature (1000 mb)
5 km
Barbados
Sea level: 1014 mb
W
E
August 13, 1963
Run 1

FIG. 13



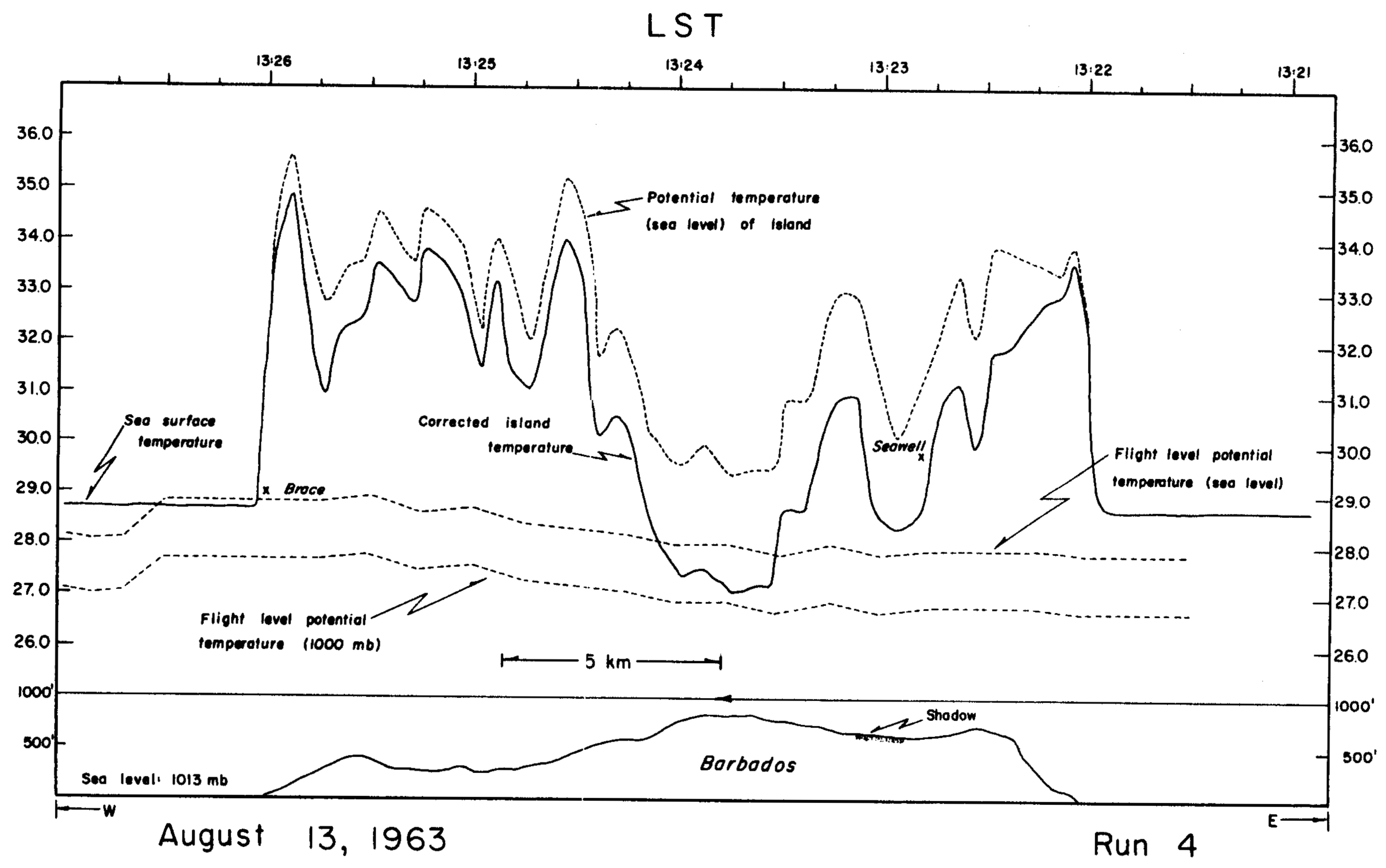
LST
08:48
08:47
08:46
08:45
08:44
08:43
T °C
29.0
28.0
27.0
26.0
25.0
1000'
500'
Potential temperature (sea level) of island
E.P. Light x
Seawell x
Brace x
Sea surface temperature
Flight level potential temperature (sea level)
Flight level potential temperature (1000 mb)
Corrected island temperature
5 km
Shadow
Barbados
Sea level: 1014 mb.
W
E
August 13, 1963
Run 2

FIG.14



LST
13:09
13:10
13:11
13:12
13:13
13:14
T °C
Potential temperature (sea level) of island
Corrected island temperature
Flight level potential temperature (sea level)
Flight level potential temperature (1000 mb)
Sea surface temperature
x Brace
Seawell x
5 km
Shadow
Barbados
Sea level: 1013 mb
1000'
500'
W
E
August 13, 1963
Run 3

FIG. 15



LST
13:26
13:25
13:24
13:23
13:22
13:21
36.0
35.0
34.0
33.0
32.0
31.0
30.0
29.0
28.0
27.0
26.0
1000'
500'
Potential temperature (sea level) of island
Sea surface temperature
Corrected island temperature
x Brace
Seawell x
Flight level potential temperature (sea level)
Flight level potential temperature (1000 mb)
5 km
Shadow
Barbados
Sea level: 1013 mb
W
E
August 13, 1963
Run 4

FIG.16

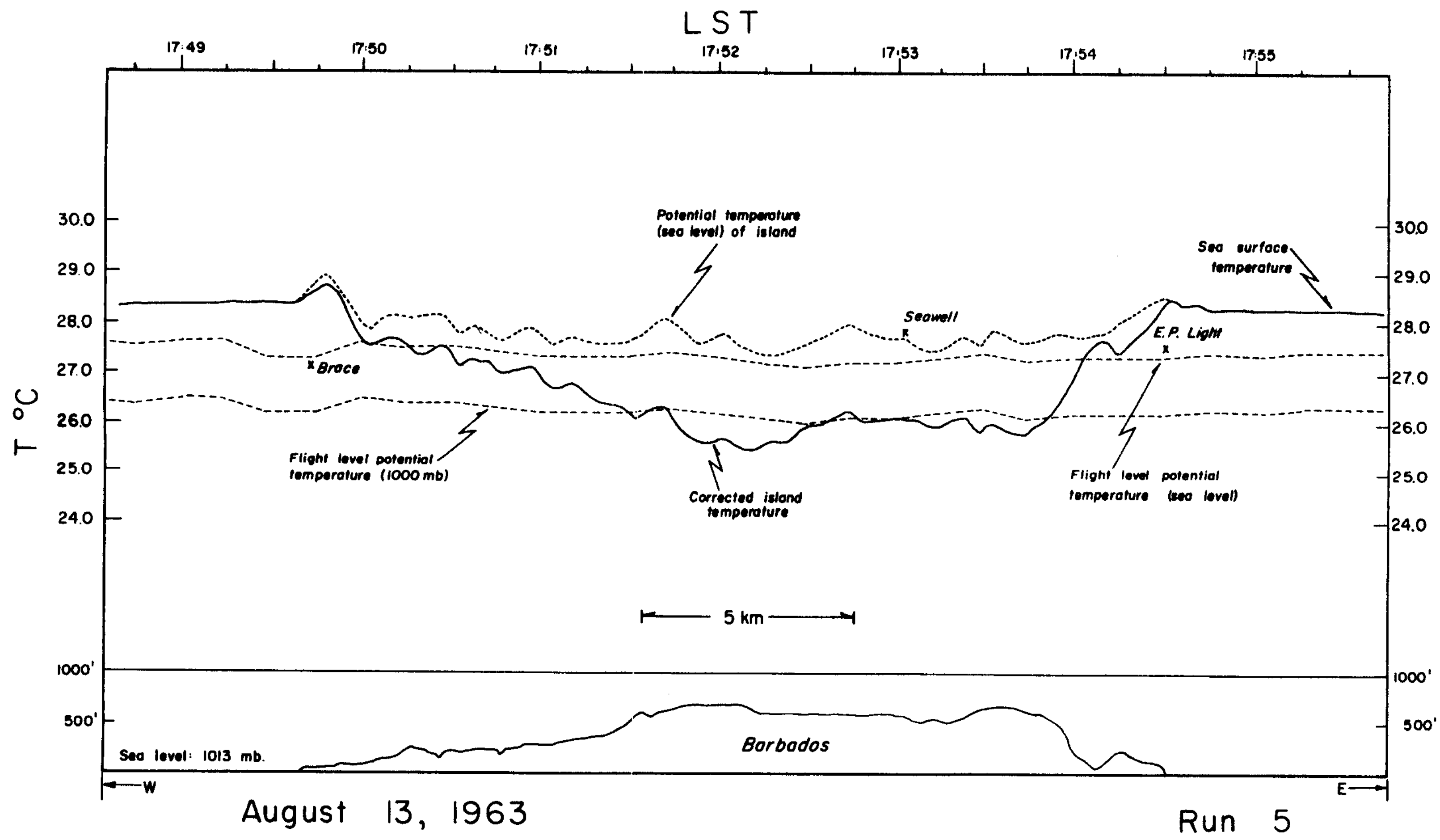
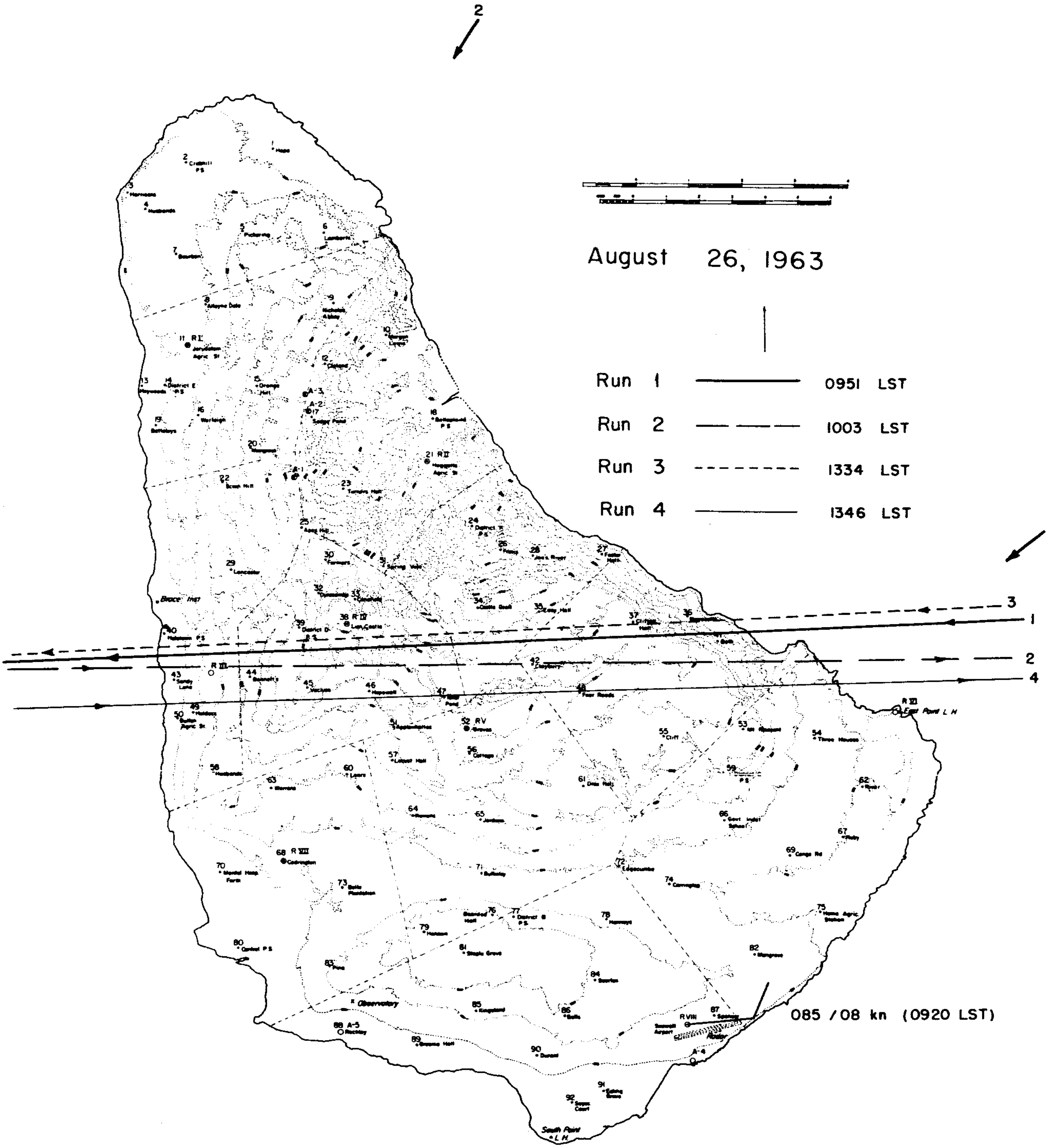
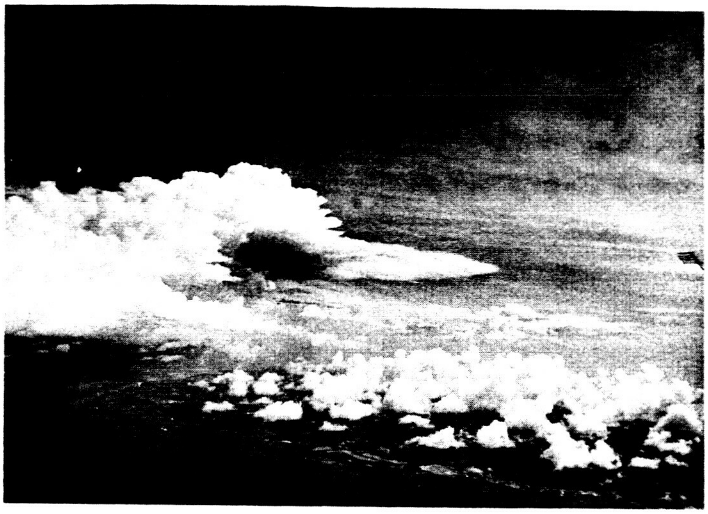

LST
17:49
17:50
17:51
17:52
17:53
17:54
17:55
T °C
30.0
29.0
28.0
27.0
26.0
25.0
24.0
Potential temperature (sea level) of island
Sea surface temperature
Seawell
E.P. Light
Brace
Flight level potential temperature (1000 mb)
Corrected island temperature
Flight level potential temperature (sea level)
5 km
1000'
500'
Barbados
Sea level: 1013 mb.
W
E
August 13, 1963
Run 5

FIG.17

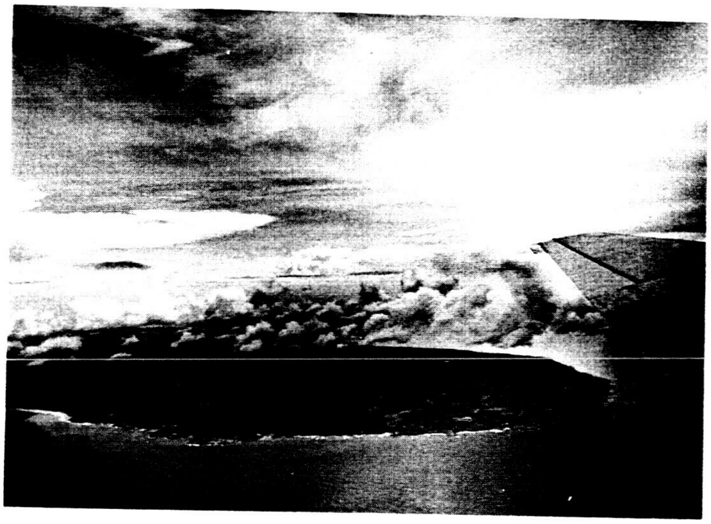


August 26, 1963
Run 1 0951 LST
Run 2 1003 LST
Run 3 1334 LST
Run 4 1346 LST
085 /08 kn (0920 LST)
Observatory
South Point L H
East Point L H

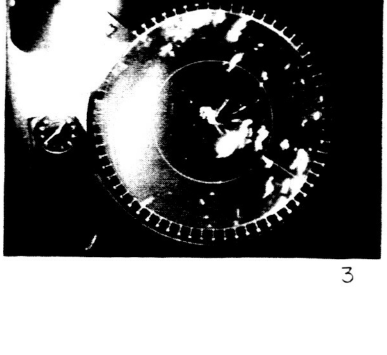
FIG. 18



1



2

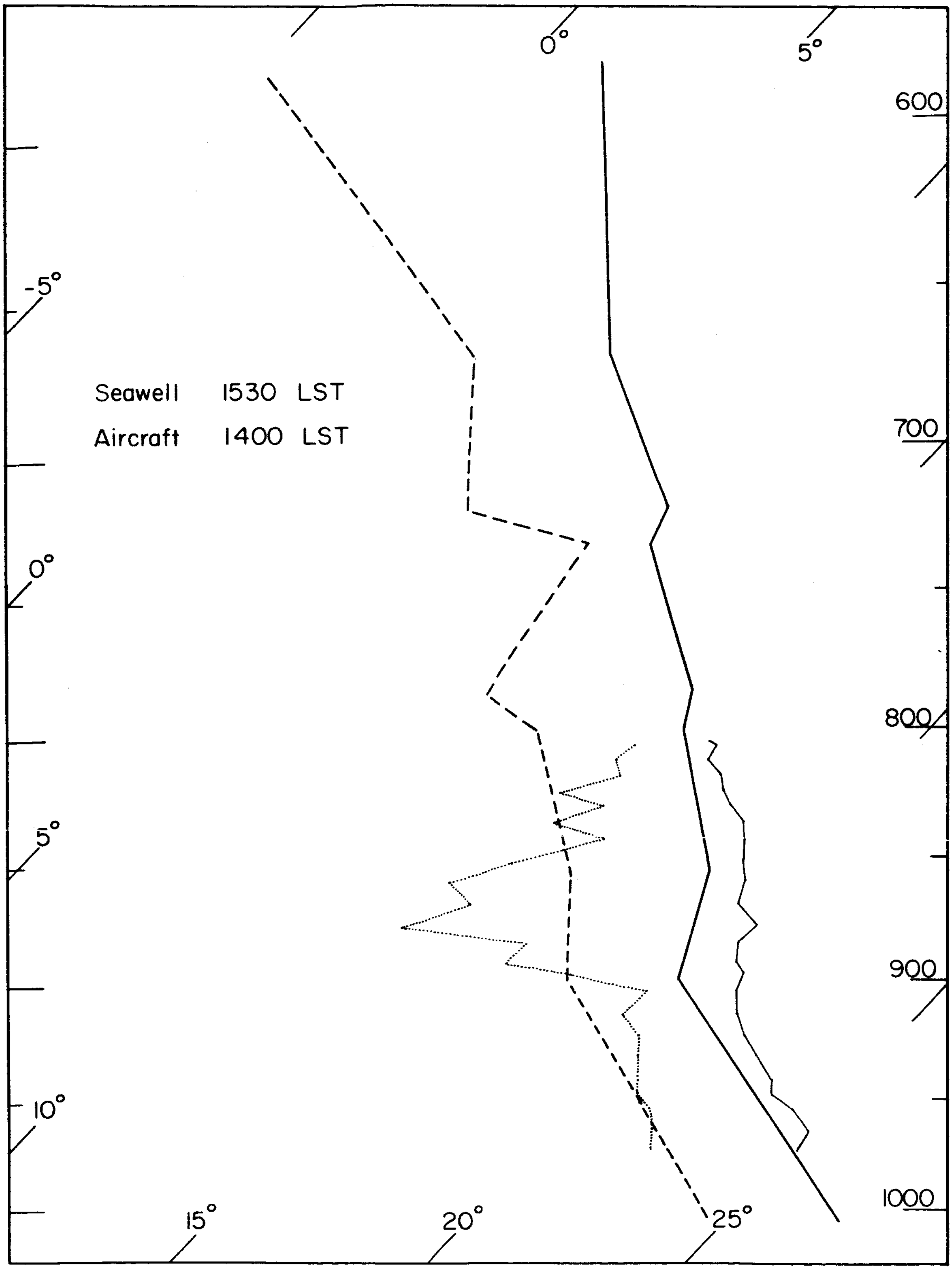


3

August 26

1300 LST

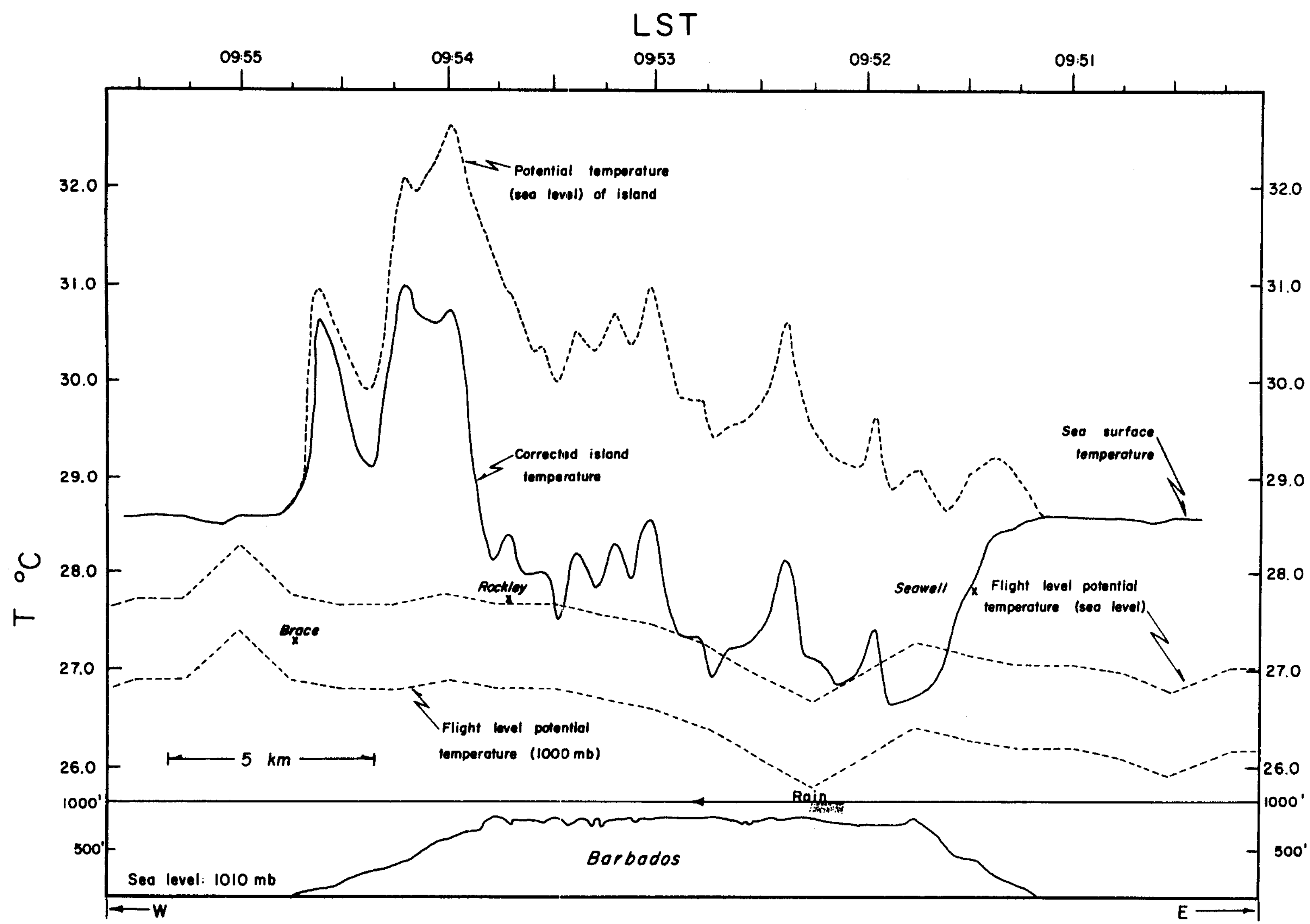
FIG. 19



August 26, 1963

Surface Wind: 085/08 at 0920 LST

FIG. 20



August 26, 1963 Run 1

FIG.21

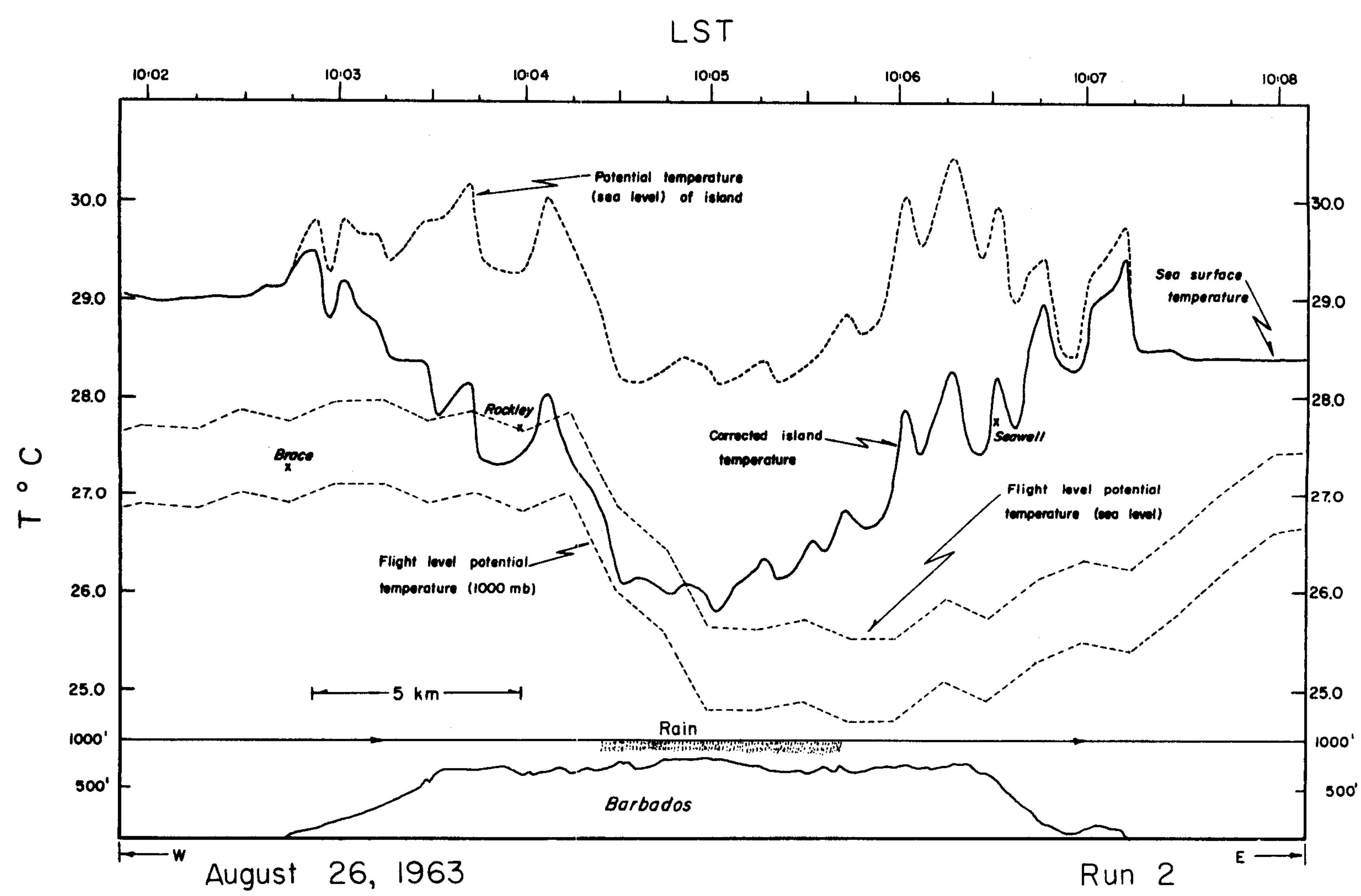
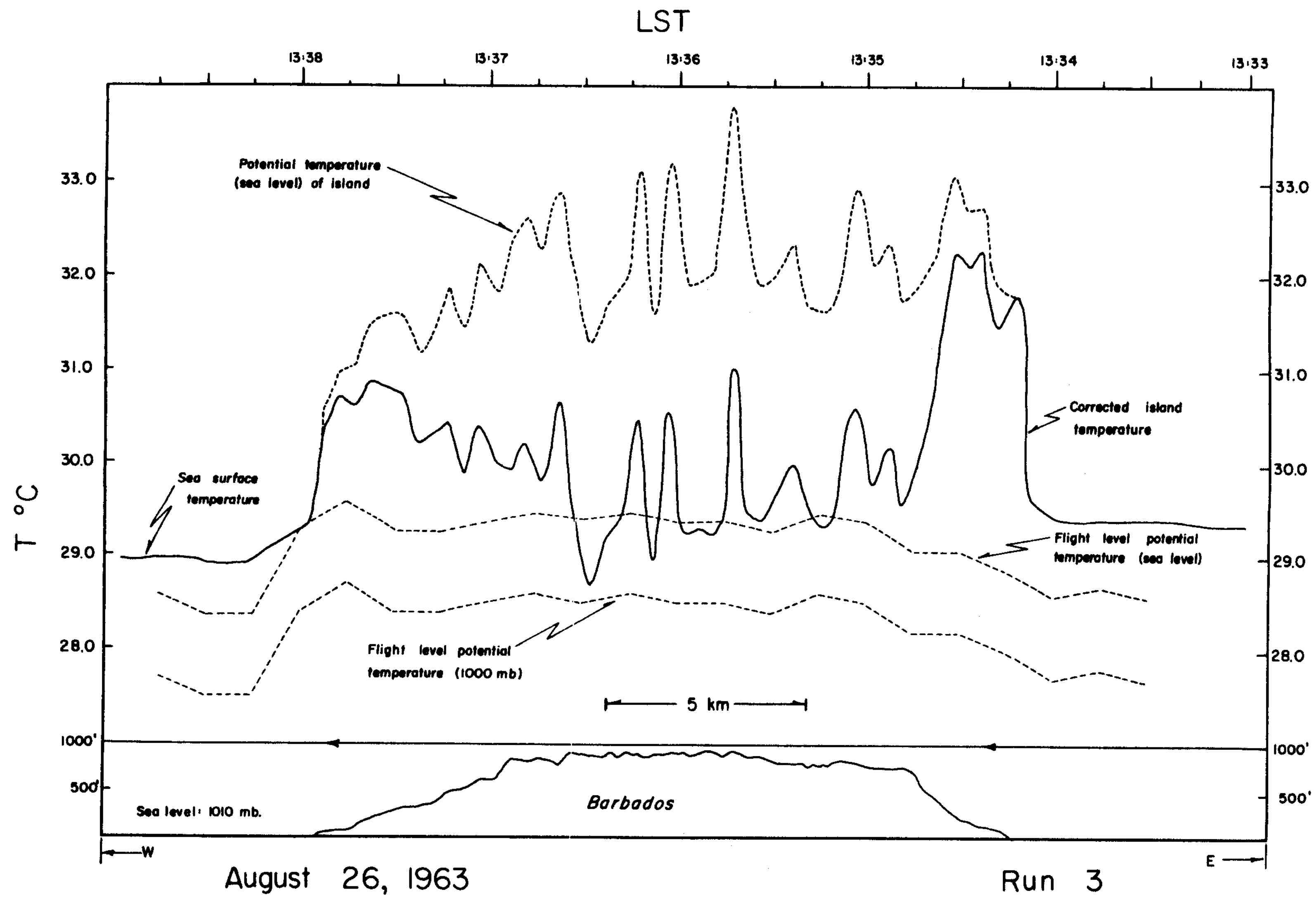

LST
10:02
10:03
10:04
10:05
10:06
10:07
10:08
T °C
30.0
29.0
28.0
27.0
26.0
25.0
1000'
500'
Potential temperature (sea level) of island
Sea surface temperature
Rockley
Brace
Seawell
Corrected island temperature
Flight level potential temperature (sea level)
Flight level potential temperature (1000 mb)
5 km
Rain
Barbados
W
E
August 26, 1963
Run 2

FIG. 22



LST
13:38
13:37
13:36
13:35
13:34
13:33
T °C
33.0
32.0
31.0
30.0
29.0
28.0
1000'
500'
Potential temperature (sea level) of island
Corrected island temperature
Sea surface temperature
Flight level potential temperature (sea level)
Flight level potential temperature (1000 mb)
5 km
Sea level: 1010 mb.
Barbados
W
E
August 26, 1963
Run 3

FIG.23

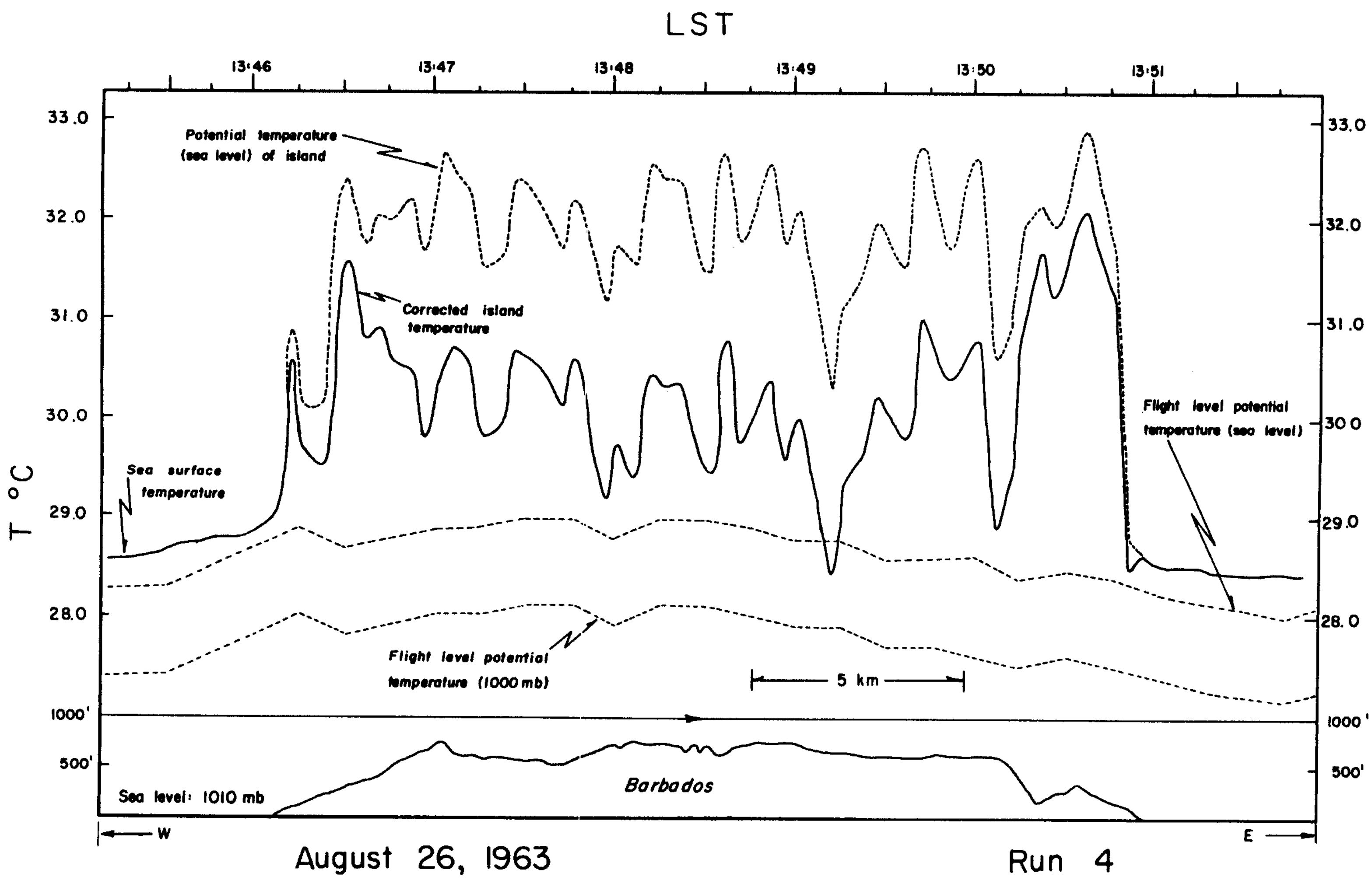

LST
13:46
13:47
13:48
13:49
13:50
13:51
T °C
33.0
32.0
31.0
30.0
29.0
28.0
1000'
500'
Potential temperature (sea level) of island
Corrected island temperature
Sea surface temperature
Flight level potential temperature (sea level)
Flight level potential temperature (1000 mb)
5 km
Sea level: 1010 mb
Barbados
W
E
August 26, 1963
Run 4

FIG.24

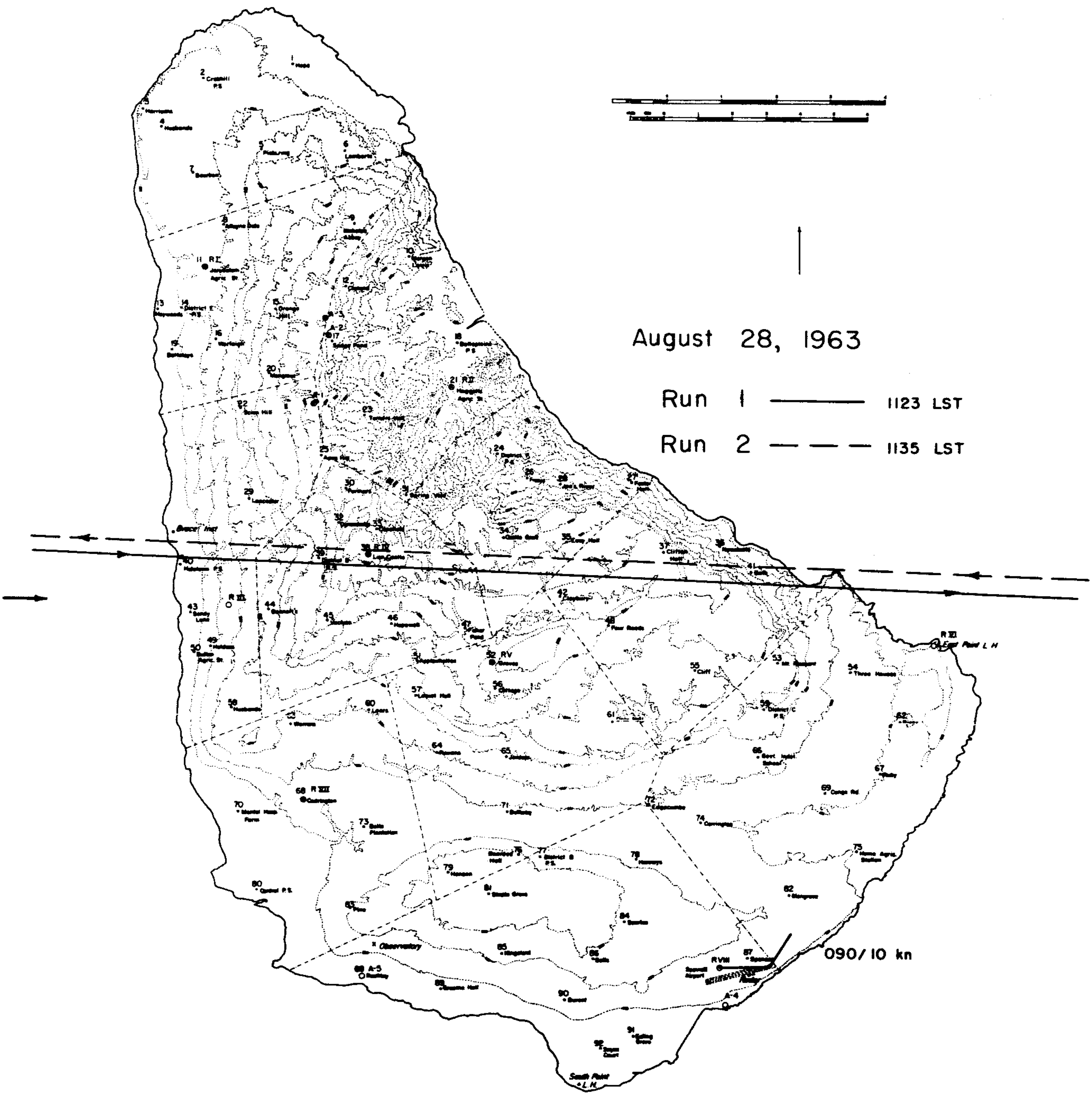
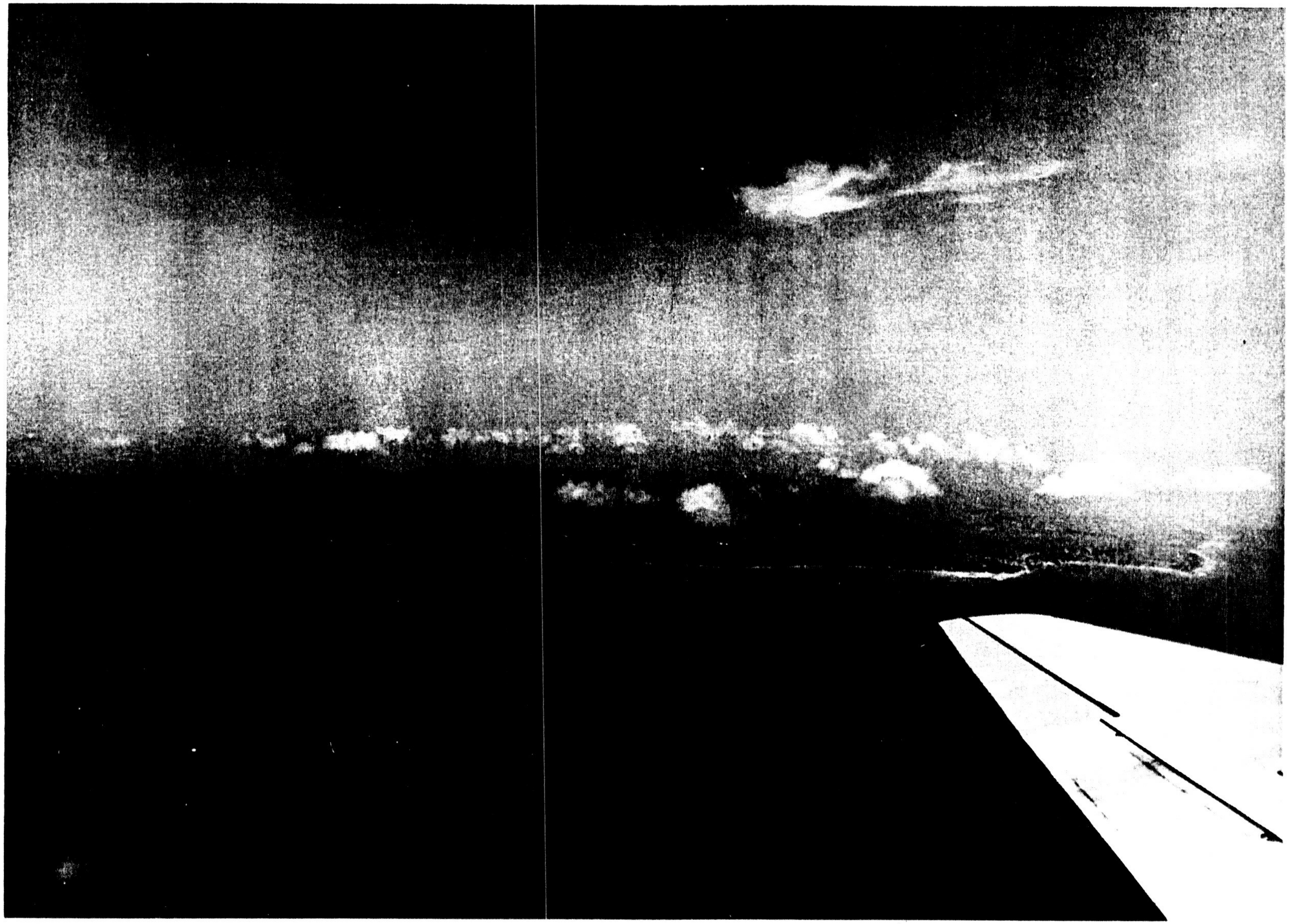
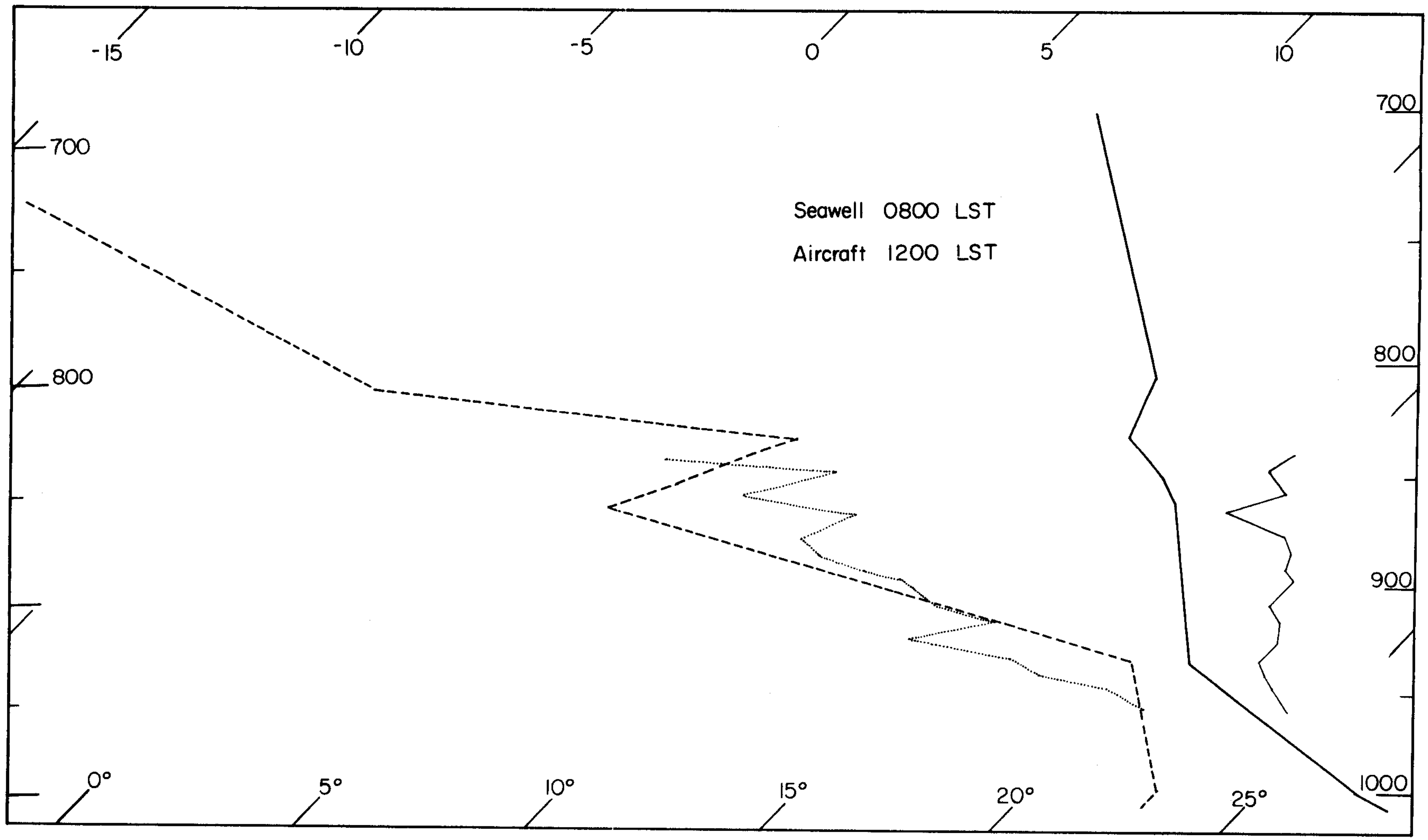


FIG.25



Aug. 28, 1963 ~ 1150

FIG.26



August 28, 1963
Surface Wind: 090/10 at 1105 LST

FIG. 27

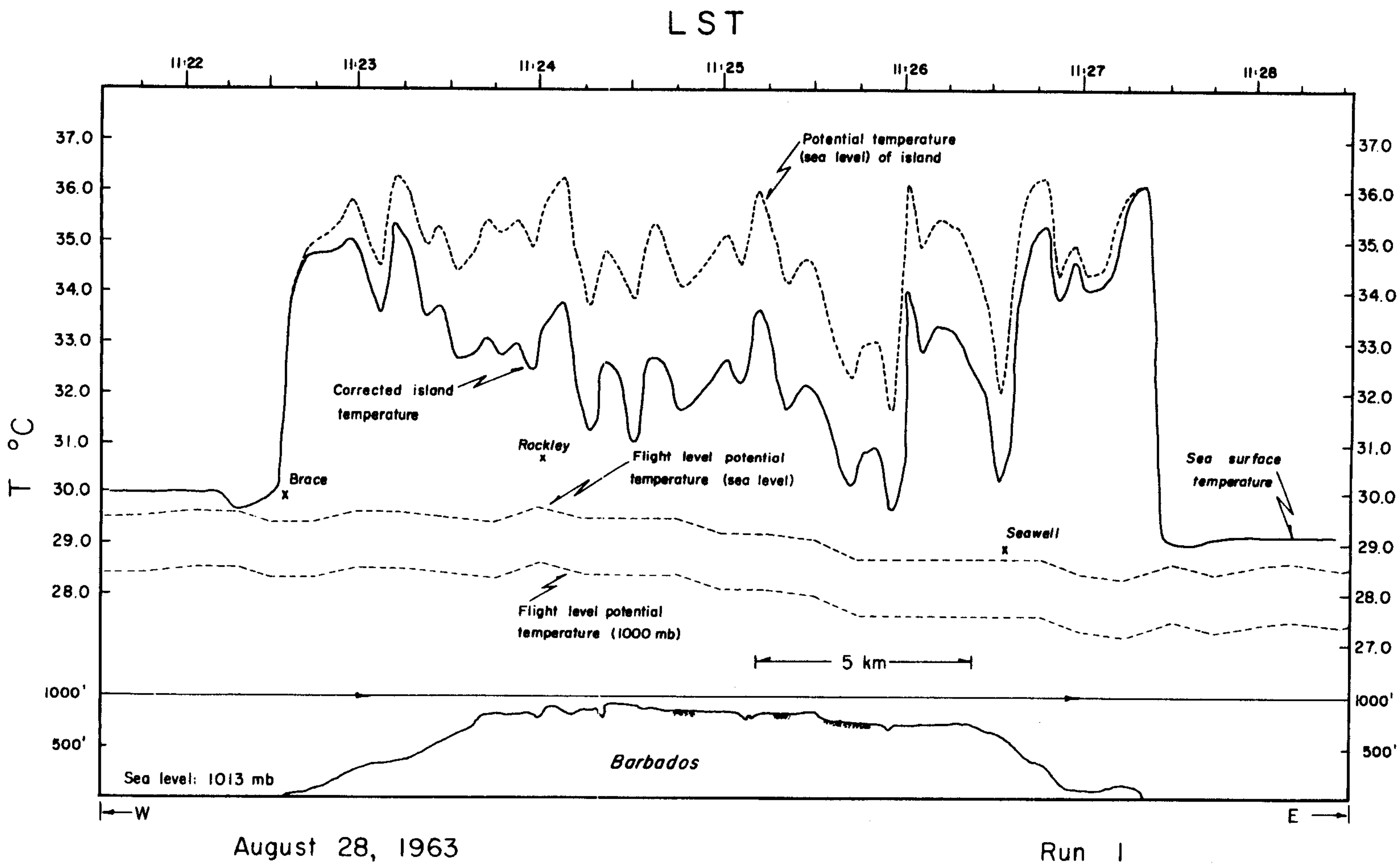
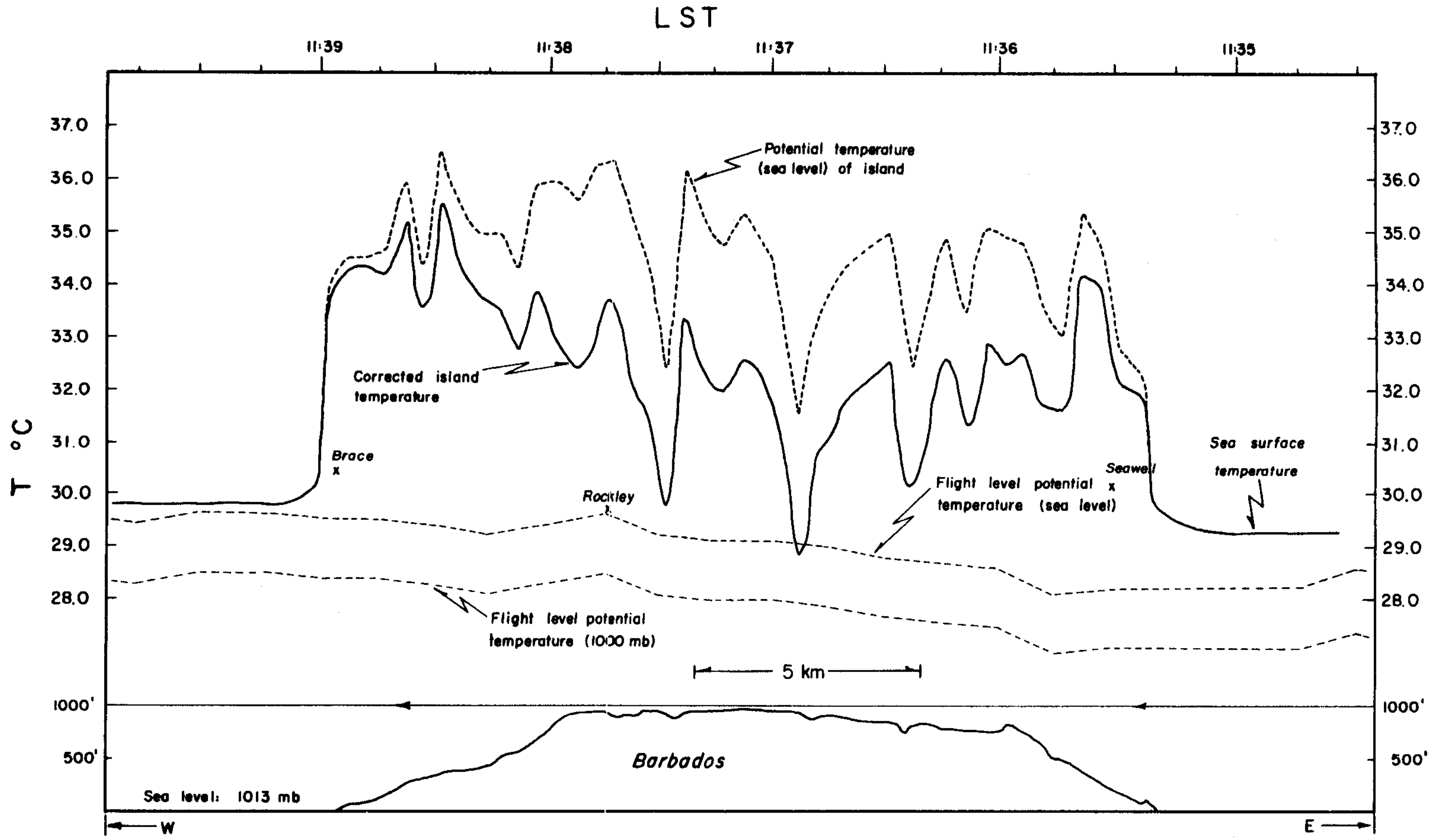

LST
11:22
11:23
11:24
11:25
11:26
11:27
11:28
T °C
37.0
36.0
35.0
34.0
33.0
32.0
31.0
30.0
29.0
28.0
27.0
1000'
500'
Potential temperature (sea level) of island
Corrected island temperature
Rockley
Brace
Flight level potential temperature (sea level)
Sea surface temperature
Seawell
Flight level potential temperature (1000 mb)
5 km
Barbados
Sea level: 1013 mb
W
E
August 28, 1963
Run I

FIG.28



August 28, 1963

Run 2

FIG.29

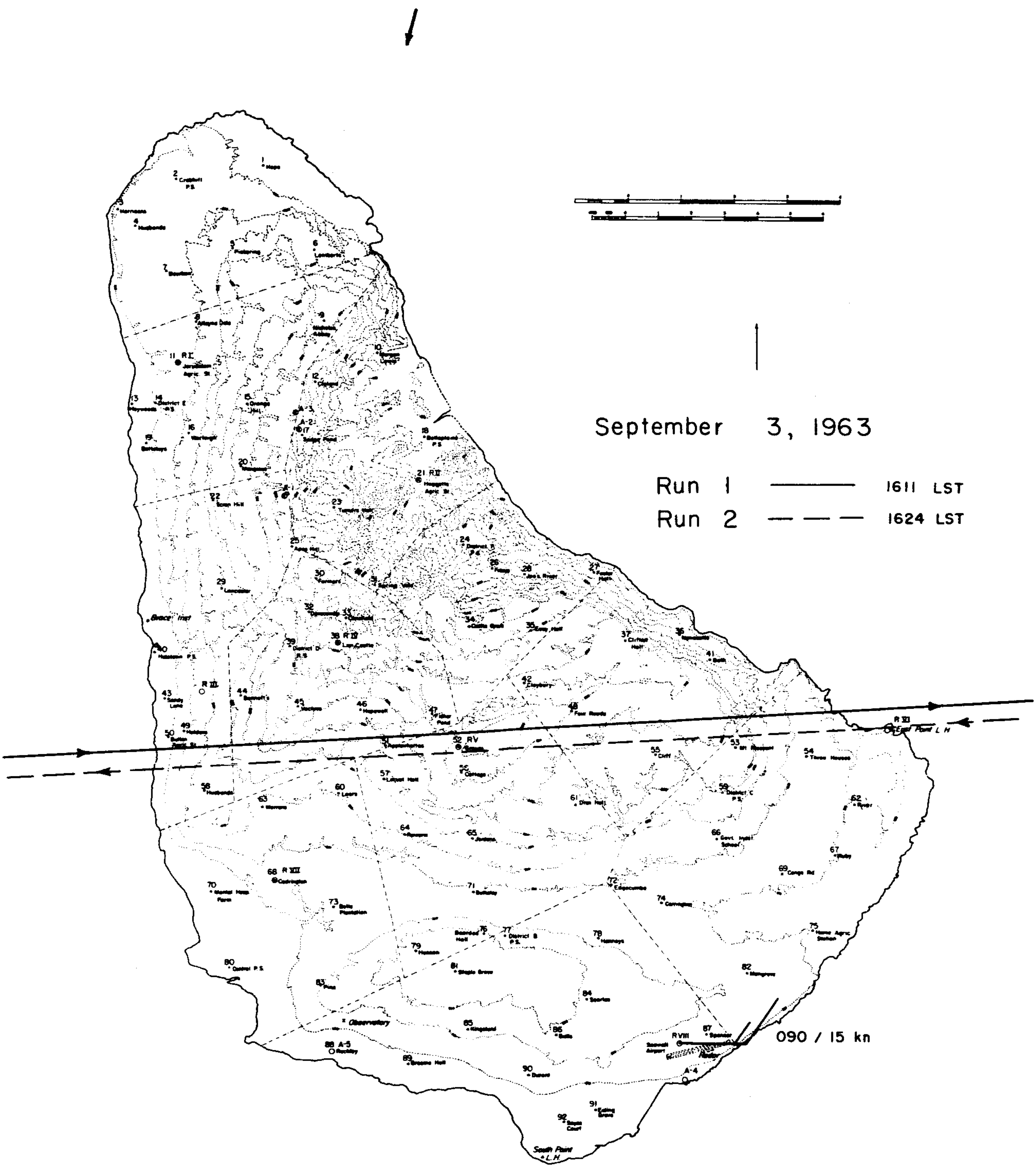
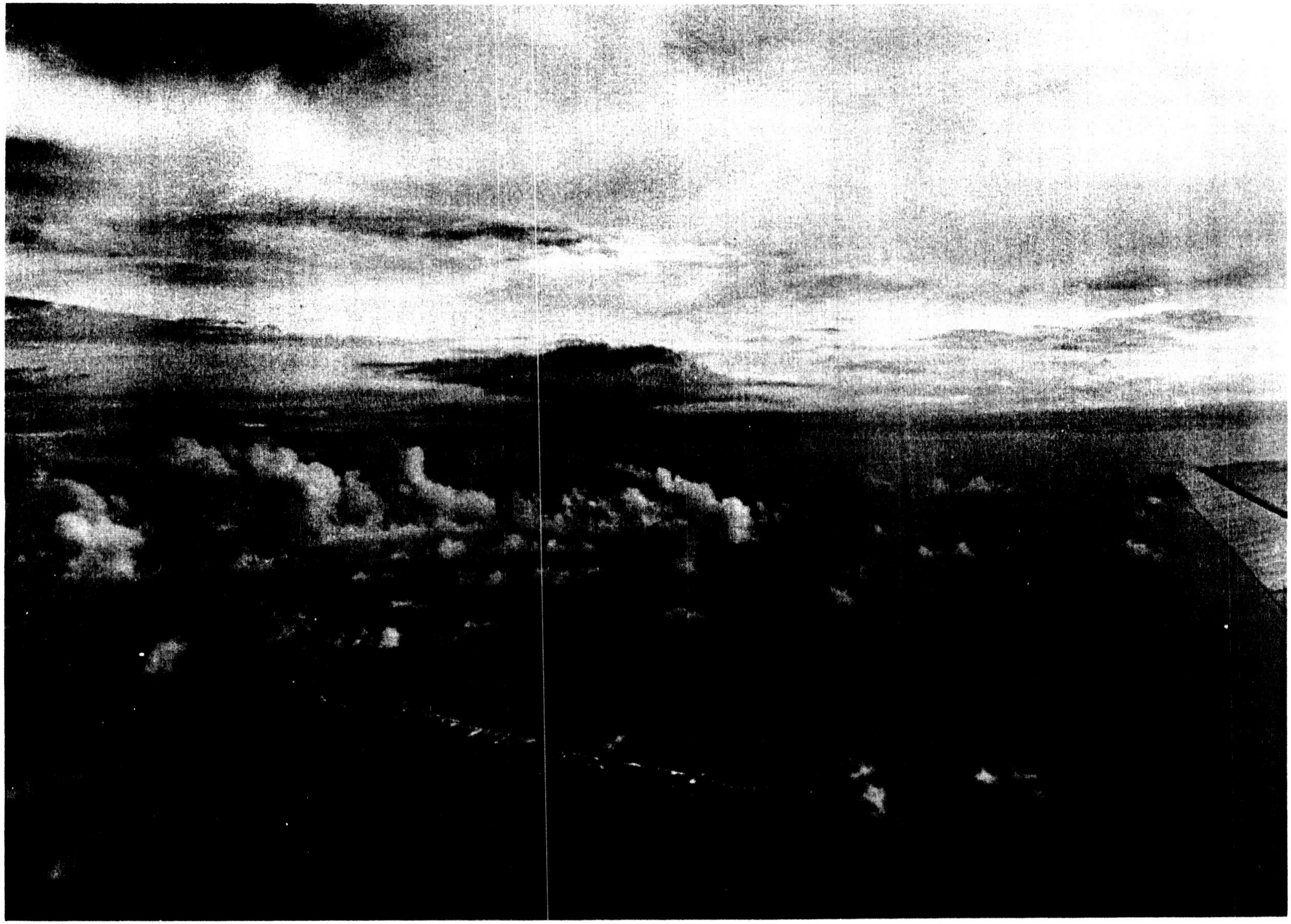
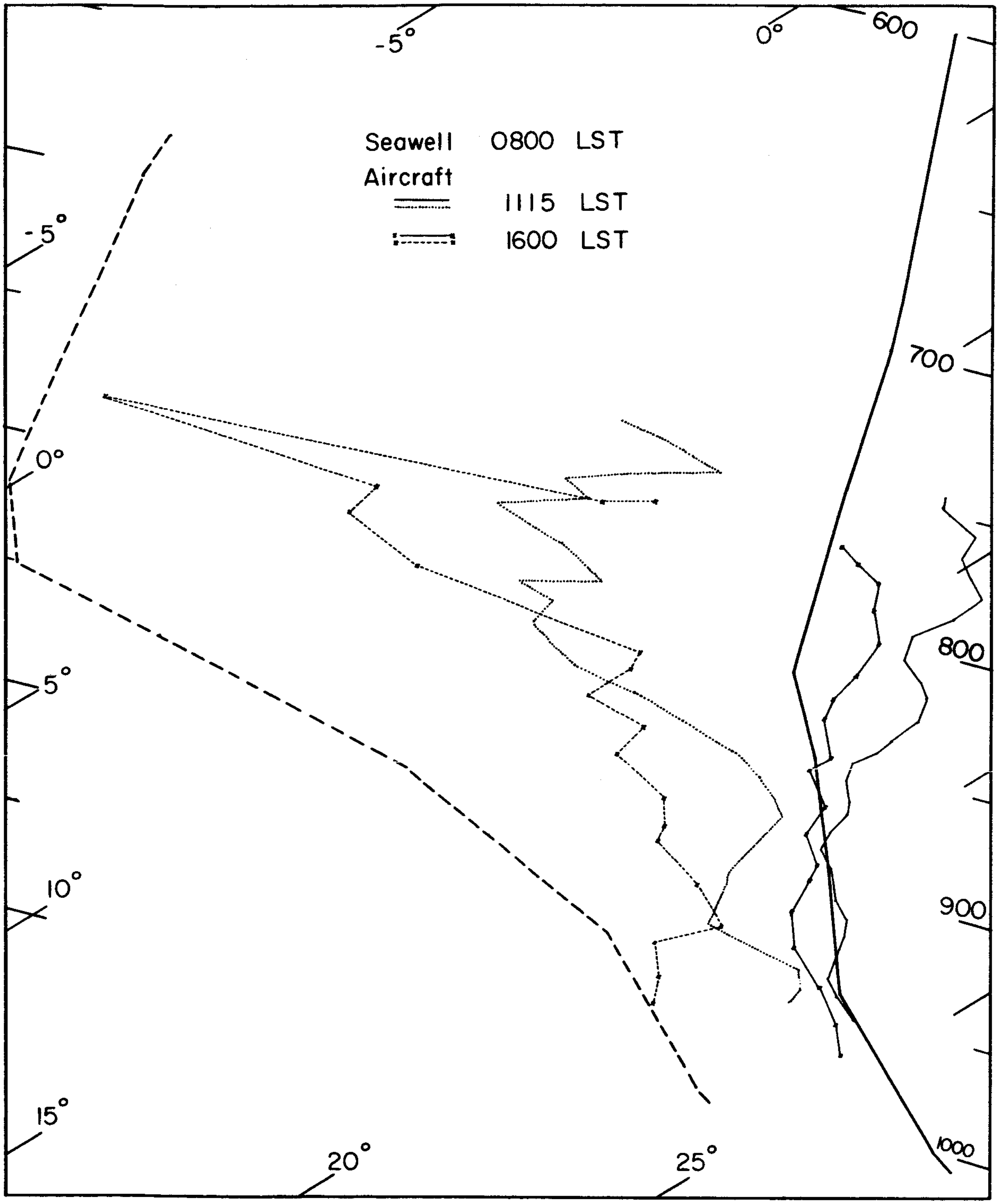


FIG.30



Sept. 3, 1963 ~ 1530

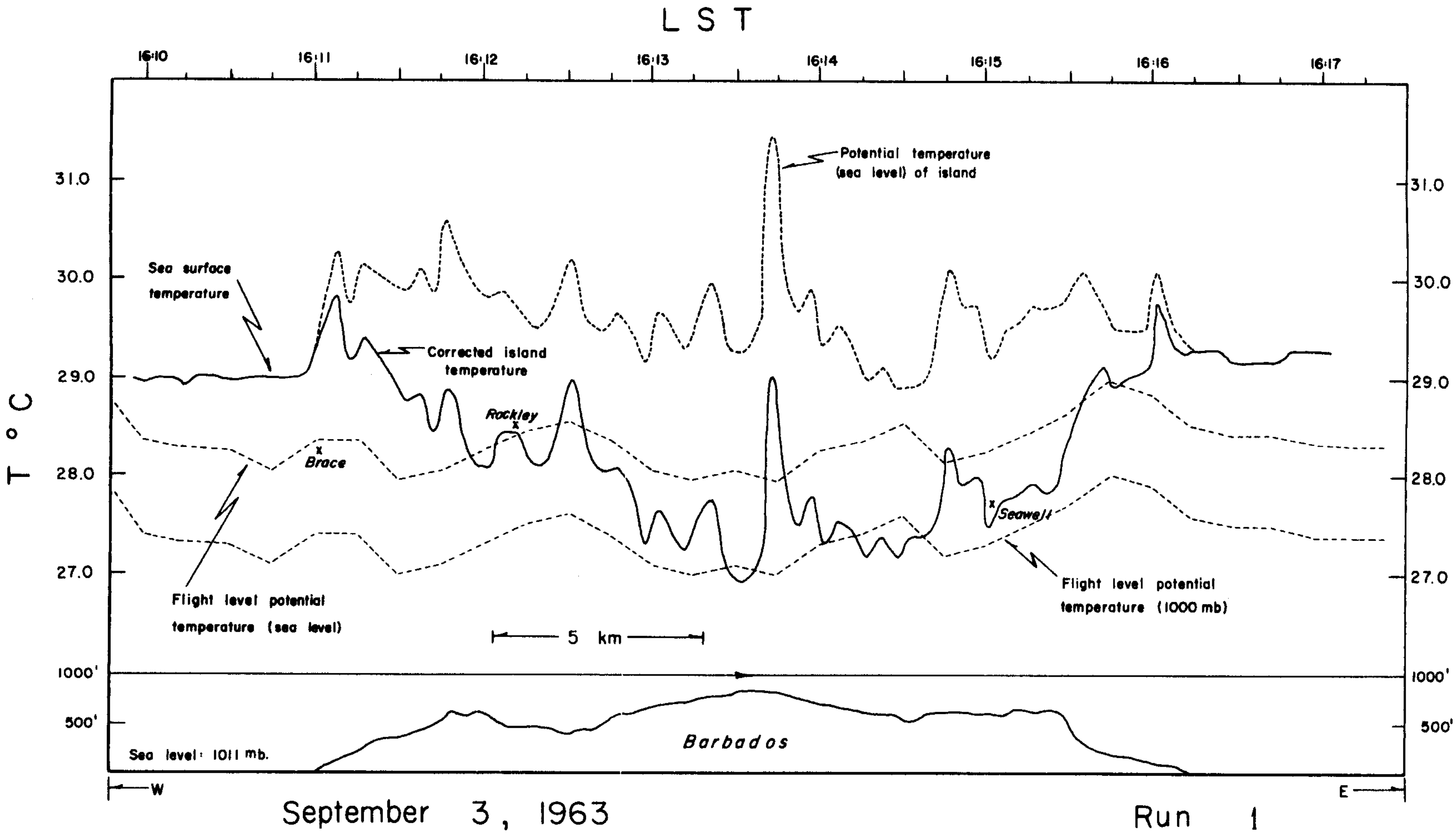
FIG. 31



September 3, 1963

Surface Wind: 090/15 at 1103 LST

FIG. 32



LST
16:10
16:11
16:12
16:13
16:14
16:15
16:16
16:17
T °C
31.0
30.0
29.0
28.0
27.0
1000'
500'
Potential temperature (sea level) of island
Sea surface temperature
Corrected island temperature
Rockley
Brace
Seawell
Flight level potential temperature (sea level)
Flight level potential temperature (1000 mb)
5 km
Barbados
Sea level: 1011 mb.
W
E
September 3, 1963
Run 1

FIG.33

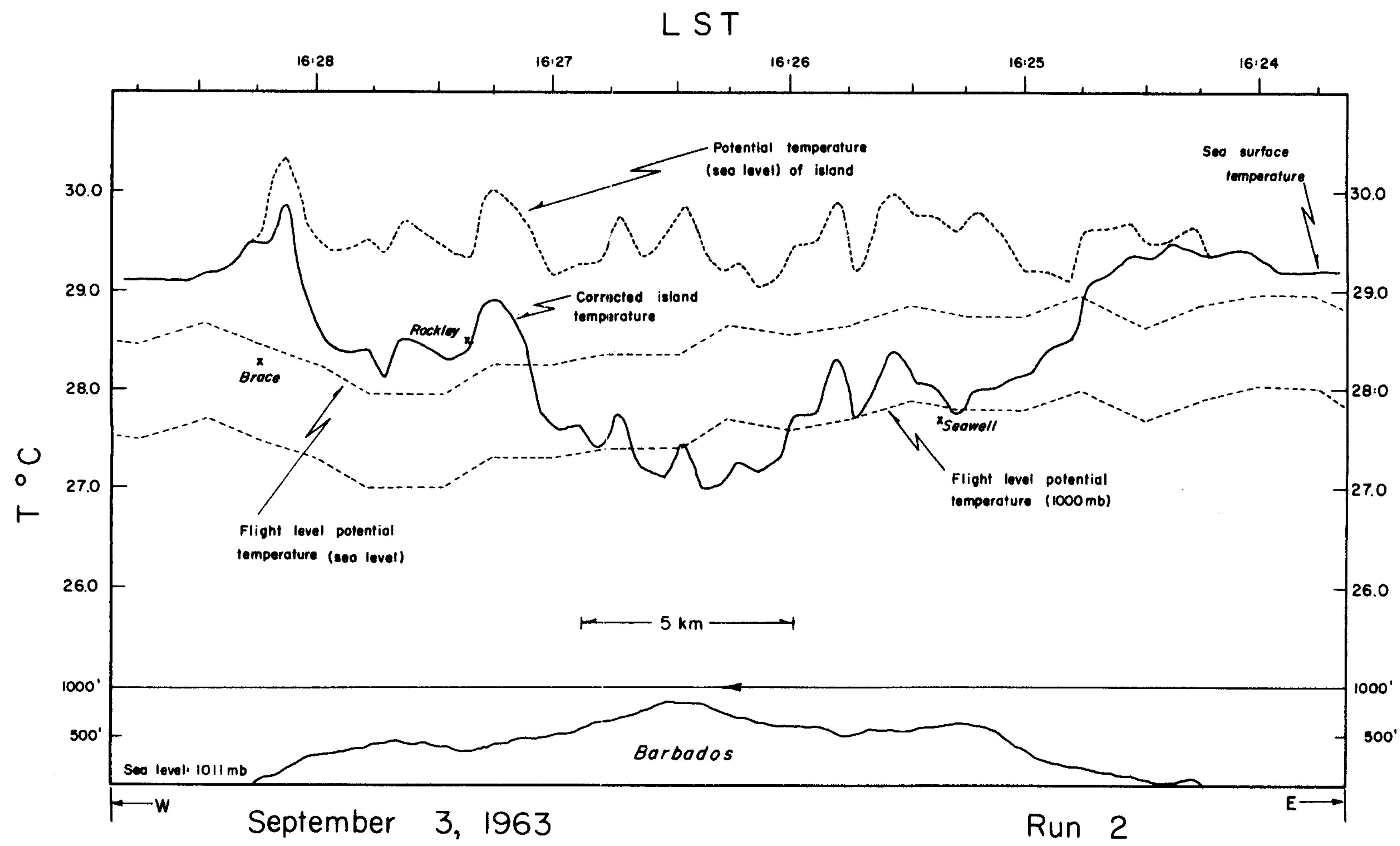
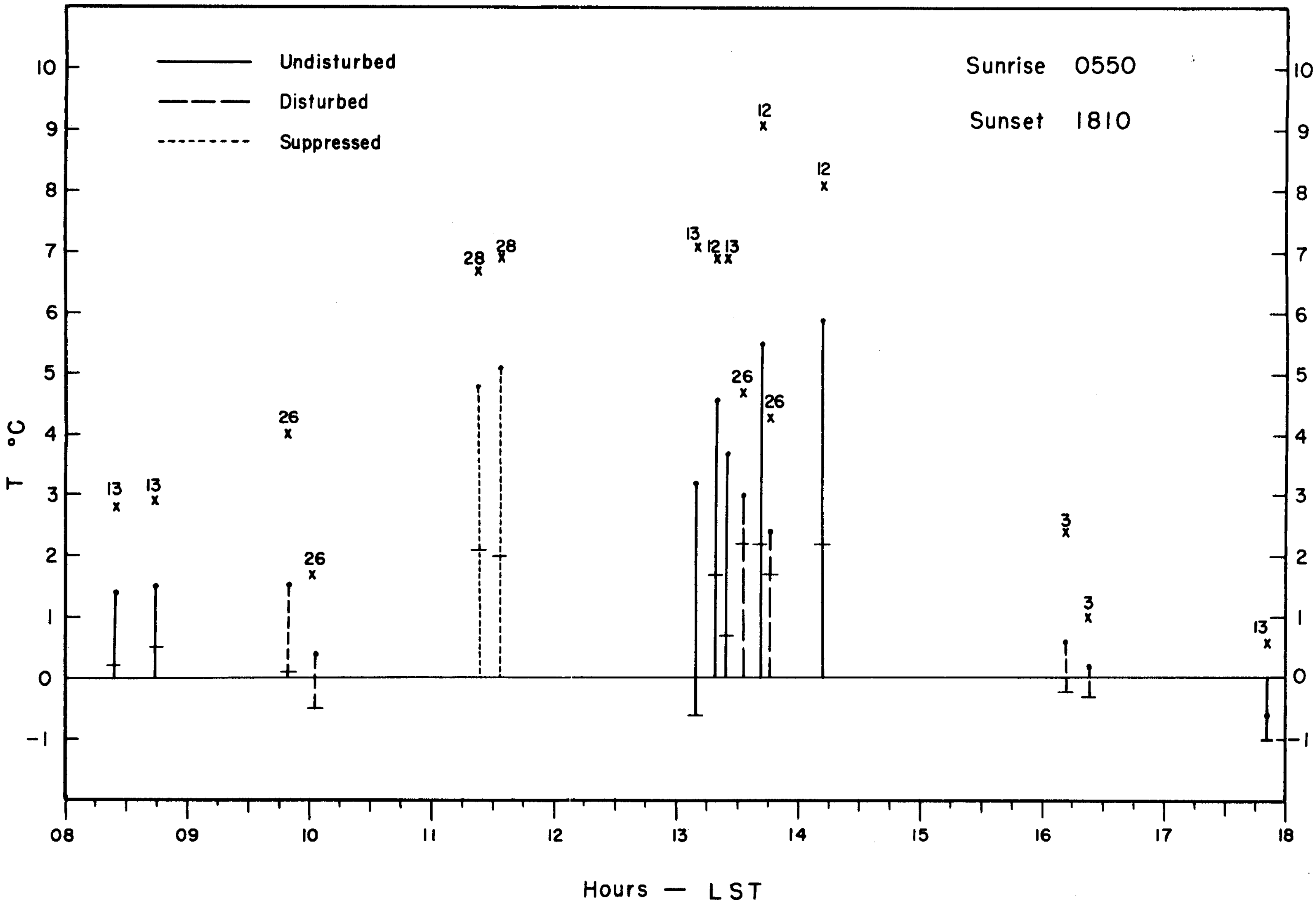

LST
16:28
16:27
16:26
16:25
16:24
T °C
30.0
29.0
28.0
27.0
26.0
1000'
500'
Potential temperature (sea level) of island
Sea surface temperature
Corrected island temperature
Rockley
Brace
Seawell
Flight level potential temperature (sea level)
Flight level potential temperature (1000 mb)
5 km
Barbados
Sea level: 1011 mb
W
E
September 3, 1963
Run 2

FIG.34



Undisturbed
Disturbed
Suppressed
Sunrise 0550
Sunset 1810
T °C
Hours — LST

FIG.35